Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

8-0521 CS

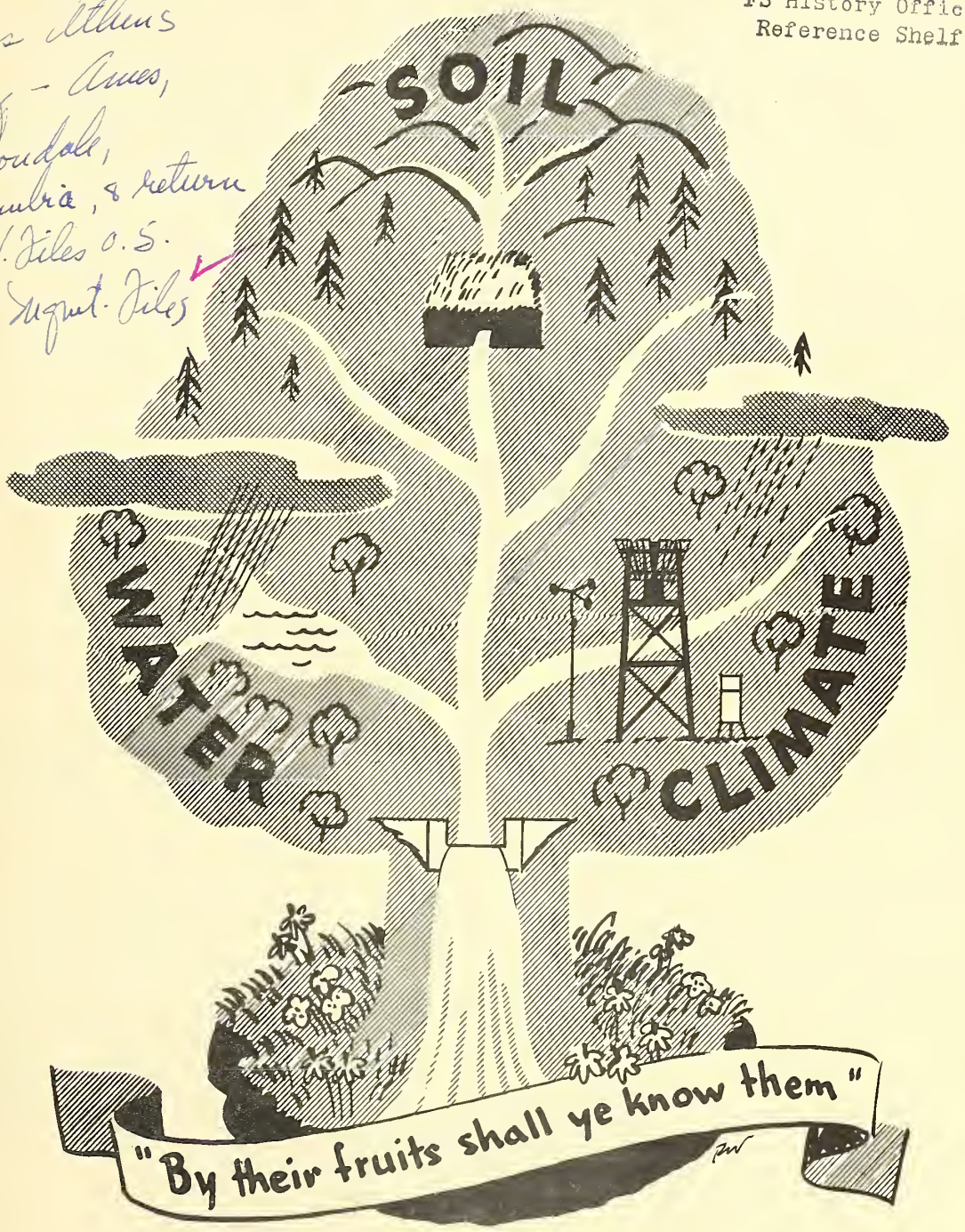
DIVISION OF WATERSHED MANAGEMENT RESEARCH

CENTRAL STATES
FOREST EXP. STA.
MAIL DESK
1954 NOV 16 PM 3:32

4 copies Reed.
2 copies Athens
1 copy - Ames, Carbondale, Columbia, & return to V. Files O.S.
1 copy August Files

Semiannual Report

FS History Office
Reference Shelf



U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

April - September 1954

DEPARTMENT OF AGRICULTURE

7432

Check No. 2

3 vols
8/18

U. S. FOREST SERVICE
DIVISION OF WATERSHED
MANAGEMENT RESEARCH

REPORTS

APR. 1954-MAR. 1956

82

INSTRUCTIONS TO BINDER

See first slip for
DIRECTIONS

Changes in title are
noted above

6973

FOR IN-SERVICE USE ONLY

SEMIANNUAL REPORT
Division of Watershed Management Research
April - September 1954

Washington Office Activities

During the past 6 months we have continued to stress long-range watershed management research needs in the light of current and forecasted trends. Expansion of the watershed protection and flood prevention program is intensifying the demand for more adequate scientific evaluation of the hydrologic and related physical effects of the measures. Silt pollution and water quality problems arising from logging and other activities on municipal water supply areas in the East and West are attracting more and more attention. Interest is sharpening in the watershed aspects of land and water conditions generally, and in more adequate research in these fields. Our response to those trends is reflected in the nature of our proposals for additional watershed management research, as discussed with the Soil-Water-Fertilizer and Forest Research Advisory Committees and their Department work groups, and with other groups.

Missouri Basin Agricultural Program

The Missouri Basin Committee wants a new look at the recommendations for watershed research as reported in House Document No. 373 (1949). We were asked to review these recommendations in preparation for a meeting of the Committee in December. Since the original estimates were prepared after considerable thinking and efforts by the stations and Washington, we felt that they should remain essentially unchanged except for a slight upward revision to reflect higher price levels, and a slight expansion in the justification statement to bring it more in line with current Department research relationships and to spell out the details a bit more.

On request, we also prepared a separate statement for consideration by the Missouri Basin research group indicating the major differences between research on the evaluation of watershed program effects, and administrative or operational studies to estimate these effects. In doing so, we emphasized that research proposals would need to meet two fundamental requirements: adequate area control (on treatment and check areas), and sufficient time to calibrate pretreatment relationships and posttreatment effects. Present provisions for evaluation are deficient in these respects and unless and until they are made adequate, it is difficult to see how the results of measurements can satisfy scientific criteria for soundness.

Hydrologic Subcommittee

In response to a request from the newly created IACWR for recommendations on the future objectives and activities of the Hydrologic and Sedimentation Subcommittees, both committees and their work groups, meeting separately and jointly, have prepared statements. On approval by IACWR the statements will be circulated in the field.

(Over)

Frank and other Department representatives participated in the recent field meeting at Cincinnati of the Subcommittees on Hydrology and Sedimentation. The group inspected the Environmental Health Center of the Public Health Service, the Ohio Basin Flood and Weather Forecasting Center of the Weather Bureau, and the Ohio River Division Laboratories of the Corps of Engineers.

The brand-new PHS Center is devoted to research and training in overcoming contamination of air, water, and food by various wastes, including radioactive materials. Laboratories provide facilities for intensive investigations in the chemical, physical, radiobiological, and engineering phases. The emphasis on environmental relationships in lab and field studies, as brought out, for example, in the discussion on stream ecology, has a quite familiar ring to the ears of watershed researchers. (cf. Tarzwell, C. M. and Gaufin, A. R. "Some important biological effects of pollution often disregarded in stream surveys." Purdue Univ. Eng. Bull. Proc. of 8th Industrial Waste Conf. May 4-6, 1953, 38 pp., 93 references, reprinted as report EHC-20 by PHS Environmental Health Center, Cincinnati, Ohio.)

Flood forecasting at the Cincinnati Weather Bureau Center has been developed to a fine point. Unit hydrographs have been prepared for drainage basins ranging from 250 - 6600 square miles. Forecasting has been greatly facilitated by use of an electronic device which routes flows (discharges) from one dam to the next on the main river and its tributaries. The device integrates discharges of the tributaries affecting given reaches of the main river; both storage and travel time are considered in this process. The rainfall-runoff relations, developed on an empirical basis, play an important part in the current success of flood forecasts.

(It is possible that these rainfall-runoff relations can be utilized by Agriculture's hydrologists in computing the effects of small watershed treatments on larger drainage areas, at least in the Ohio Basin. Assuming the data are applicable, it would only be necessary to develop relations for watersheds up to 250 square miles, relying on the WB data for larger areas. Bill Shannon, SCS hydrologist who also attended the conference, agreed that the possibilities were promising enough to warrant looking into.)

The demonstration of nuclear devices for measuring soil moisture and density at the CE laboratories kept the group interested long past quitting time. The tests here--involving the same type of probes as tested at Vicksburg by the Infiltration Project--are concentrating primarily on compacted subsoils such as are encountered at airport sites, etc. The results are considered fairly satisfactory for the Corps' purposes, but many operating difficulties remain, and frequent calibrations are necessary; background radiation, and fading due to decay of the radioisotopes complicate the analyses of the measurements. (A draft report prepared by FS and Waterways Experiment Station personnel, and now being reviewed prior to final release, discusses these problems in detail. It concludes that lack of sensitivity, erratic performance, and other deficiencies will need to be overcome before this method can become practical for field use.)

Agriculture Yearbook

Articles for the Water Yearbook are rolling in. Editor Stefferud has been kind enough to let us see some of them. Others have been routed to us in rough draft by the authors for such comments as we might see fit to make. We shall be glad to comment on any articles that might come our way, but responsibility for clearance, of course, remains with the stations. Our own write-ups are gradually shaping up. We expect the contributions by watershed management researchers to add materially to the quality and authoritativeness of this objective compendium of useful knowledge on a field of tremendous importance. We are confident that this yearbook will greatly improve the public understanding of watershed management in its broadest sense, including, of course, the research aspects. The circulation of the yearbook and its reprints is far greater than that which most of our reports and articles receive, thus providing excellent opportunities for getting our stuff across to a large and new audience.

Miscellaneous

In August another group of around 20 Turkish foresters took the Washington orientation course prior to leaving for field training. As on previous occasions, the watershed management research lecture was illustrated with the color slides which have proved so valuable on other occasions. The interpreters did an excellent job of translating the remarks, judging by the nature of the questions asked.

We also had an opportunity to review and to revise a biology teacher's guide scheduled for early publication. The detail into which the statements went on plant-soil-water relations indicates a rapidly growing appreciation of this field by the science teachers in our high schools.

The D. C. Section of the Soil Conservation Society of America has set up a Rock Creek Watershed Committee chairmanned by Bernie Frank, to stimulate local action on the serious watershed and recreational problems in that area. Frank has written a couple of articles and given half a dozen color slide lectures thus far before conservation and civic groups on conditions, causes, and remedies. The Interstate Commission on the Potomac River Basin is interested in the project, and the indications are that it will join with the Washington Chapter of the Soil Conservation Society and other groups in sponsoring the formation of a watershed association.

Herb Storey acquainted a large group of interested listeners at the annual meeting of the Pennsylvania Forestry Association at Penn State College with the watershed management research program of the Forest Service. His talk has since been published in the summer issue of Pennsylvania Forests under the title "Water Problems and Watershed Management."

Several students pursuing or planning to undertake advanced studies in watershed research have asked for guidance. Naturally we have been glad to advise them on what courses to pursue, or to review research proposals.

Have You Seen?

Whetstone, George A. "Mechanism of Ground Water Discharge." Agricultural Engineering, Vol. 35, No. 9, Sept. 1954, pp. 646-647, 650.

Vamocil, James A. "In Situ Measurement of Soil Bulk Density," pp. 651-654, above publication. (Discusses nuclear probes; compares merits of two-probe unit vs. one-probe unit; the former permits more sensitive determinations for layers two inches thick and up, as on the surface; frequent calibrations with standard needed in both bases.)

Ellison, Lincoln and J. E. Coaldrake. "Soil Mantle Movement in Relation to Forest Clearing in Southeastern Queensland." Ecology, Vol. 35, No. 3, July 1954, pp. 380-388. (This article analyzes some of the phenomena involved in landslides and related surface deposit movements in mountain forest and other areas.)

Jumikis, A. R. "Suction Force in Soils upon Freezing." Proc. A.S.C.E., Vol. 80, No. 445, June 1954, pp. 445-1 to 445-14. (Based on laboratory experiments in connection with studies of road surfaces; article gives 18 references on frost, including foreign.)

Thornbury, William D. "Principles of Geomorphology." John Wiley and Sons, 1954, 618 pp.; an illustrated textbook; applications (re roads, etc.) are discussed on pages 571 ff.

Jenkins, D. S. et al. "The Origin, Distribution, and Airphoto Identification of United States Soils (with special reference to airport and highway engineering)," Technical Development Report No. 52, May 1946, U. S. Department of Commerce, Civil Aeronautics Administration, Washington, D.C. 202 pp. multi. (Also Appendix B of this report which contains stereopairs and single air photos illustrating the discussion in the main report. These reports are mentioned in case you may not have noted them before.)

Discussion

The SE Progress Report for Oct.-Dec. 1953, pp. C-8-10, contains some generalizations on the effects of logging which raise some questions. The statement begins by questioning the conclusions of flood control specialists on the value of approved logging methods in reducing storm runoff and concludes that "Perhaps more emphasis should be placed on woodland management and logging methods from the standpoint of sedimentation and water quality rather than reduction in runoff." The behavior of Coweeta No. 10 is cited as evidence.

Unfortunately, no data of a comparable nature are presented for the watersheds of the Pee Dee, Savannah, and Delaware Rivers examined by the flood surveyors referred to, to indicate the extent of their similarity to the conditions resulting from the treatment of No. 10. We are given no idea as to how representative No. 10 may be of other areas throughout the Southern Appalachians and Northeast. Nor have we seen as yet any full description of the conditions within No. 10 itself, aside from those directly associated with the logging roads. For example, we have no information on the extent of area bared by skidding; the effects of logging on compact and on litter depth and distribution as compared with the unlogged control. No mention is made of the possibly

significant differences--even if other conditions were assumed to be equal--which might result from large-scale vs. small-scale logging, machine vs. horse skidding.

It is possible, of course, that the conclusions stated may be valid for other areas. But until we have other data--until adequate comparisons are made on a quantitative basis--it is difficult to accept the generalizations.

Incidentally, the conclusion in the Oct.-Dec. 1953 report appears to conflict with a statement in the SE Quarterly Progress Report for Oct.-Dec. 1951: "A considerable change has taken place in the last nine years on logging methods... In 1942...skidding was with oxen and horses. After World War II the emphasis changed...to power skidding.." After referring to the occurrence of landslides from past logging on steep, unstable slopes in the Southern Appalachian Mountains, the report states that "We now believe that there are special areas that should be excluded from cutting...," and recommends a classification system to minimize future hazards.

It is true that erosion (landslide) rather than flood hazards were stressed in the 1951 report, but one cannot help drawing the inference that storm flows incident to the serious soil disturbances described would be higher than before.

I am also puzzled as to how we would "place emphasis" on logging methods "from the standpoint of sedimentation and water quality rather than reduction in runoff." For example, would such a proposal indicate the use of desilting structures after the runoff concentrated in channels, rather than the prevention or control of surface runoff and erosion on the logging area itself?

--Bernard Frank

We're still interested in receiving copies of or references to color slides, especially of activities, areas, methods, devices, results, on the newer projects.

SEMIANNUAL REPORT -- APRIL TO SEPTEMBER 1954

Division of Watershed Management Research

California Forest and Range Experiment Station

GENERAL

Watershed management in the California Station was enlivened by several activities during the past six months:

1. The Region Five Forest Service Advisory Council met on the Sierra National Forest in July with a major part of its program devoted to water. Jemison and Colman attended, along with representatives from the Regional Office and the Sierra N. F. Operations and plans of the Southern California Edison Company and the Pacific Gas and Electric Co. were discussed on the ground with members of these companies. Both company and council members expressed interest in the Station's recommendations for research in snow-pack management. The possibility of delaying snow melt by forest management was particularly appealing to the company people, who stated that any slowing of spring runoff and any increase in summer flows would aid their hydro operations. The Edison Company operates a series of reservoirs from the headwaters to the valley on the San Joaquin River. The Pacific Gas and Electric Co. is about to construct dams in the headwaters of the North Fork of Kings River for power generation, supplementing their present operations lower on the same river.

2. The State Division of Water Resources is showing interest in snow research. Medill Thiebaud, one of the Division's engineers, spoke at the June field meeting of the Society of American Foresters, and commented favorably on the plan for snow research submitted to the State Department of Natural Resources last spring (see Semiannual Report October 1953 - March 1954). Discussions with other members of the Division have also showed this interest.

3. The Station was asked to cooperate with the Pacific Gas and Electric Company in planning a timber harvest on a company-owned watershed near Willits, Mendocino County. The primary requirements in this harvesting are that watershed protection be unimpaired, and, if possible, that water yield be improved. The Station agreed to cooperate, but no action has yet been requested by the company.

4. The Sacramento District of the Corps of Engineers has agreed to transfer the Central Sierra Snow Laboratory to the Station for use in snow research. While formal transfer action has not yet been taken, maintenance of the Laboratory buildings is now in our hands. We requested this transfer because the Corps was about to dispose of the Laboratory, and we thought it should be preserved until we learned whether the Station or some other organization would have funds to reactivate it. The Laboratory, covering a 4-1/2 square mile watershed, has been the scene of detailed snow studies since 1946, and has yielded data which would provide excellent leads for snow management research there in the future.

5. We have been informed by the Western Forestry and Conservation Association that one session of its annual meeting this December will be devoted to watershed management. Colman has been invited to tell all about Forest Influences in 15 minutes.

6. The Environmental Analysis Section, Headquarters Quartermaster Research and Development Command, U. S. Army, has sent the Station an invitation to participate in a comprehensive research program on soil temperature, under contract with the Command. The Section is interested in any research which will lead to methods by which surface soil temperature can be predicted for various conditions of topography, cover, soil, and climate. As stated in the invitation, "Soil temperature directly affects conditions of storage and operation of material by contact, and indirectly affects them through its relation with the local climate." A group of nine studies was submitted and the suggestion added that other Experiment Stations should also be contacted.

7. Three members of the Division's staff have been called upon to contribute chapters for the Department of Agriculture's next Yearbook. Sinclair, with Craddock of the Intermountain Station, is writing "Floods from Western Mountain Lands". Gleason, with Packer of the Intermountain Station and Hockensmith of the Soil Conservation Service, is writing "Indications of a Damaged Watershed". Colman is working on two chapters: "The Water Cycle", with Ackermann of ARS and Ogrosky of SCS, and "Soil Surveys on Mountain Forest and Range Lands" with Retzer of the Rocky Mountain Station. At last report the authors were resting uncomfortably.

8. During July research activities on the San Dimas Experimental Forest and the Los Angeles River watershed were reviewed by H. C. Storey and Director Jemison (and Storey later spent a week in and out of Berkeley). Administrative functions were reviewed by George Haney, and Clyde Walker discussed technical writing with the San Dimas staff. A safety inspection was made by Seth Jackson, Washington Office, and Joseph T. Radel, Region 5. In August a group headed by Edward Cliff, Washington Office, Clare Hendee, Region 5, and Director Jemison reviewed research activities on the San Dimas Experimental Forest as a part of their inspection of watershed management activities of the Forest Service in southern California.

PERSONNEL

Jerome S. Horton has accepted a transfer to the Southern Forest Experiment Station where he will serve as officer-in-charge of the Vicksburg Infiltration Project. Horton left on September 7 for his new assignment.

Henry W. Anderson transferred his headquarters from Pasadena to Glendora to take over part of the duties previously assigned to Horton. Anderson will continue to devote half of his time to the Soil Movement Study.

PUBLICATIONS

Manuscripts Published

"Fire-Flood Sequences on the San Dimas Experimental Forest," California Forest and Range Experiment Station, Technical Paper No. 6, March 1954, 29 pp., illus., by the staff of the San Dimas Experimental Forest.

"Erosion in the San Gabriel Mountains of California," Transactions, American Geophysical Union, Vol. 35(2), (April 1954), pp. 264-268, illus., by J. D. Sinclair.

"Suspended Sediment Discharge as Related to Streamflow, Topography, Soil, and Land Use," Transactions, American Geophysical Union, Vol. 35(2), (April 1954), pp. 268-281, illus., by H. W. Anderson.

"Major Brushland Areas of the Coast Ranges and Sierra-Cascade Foothills in California," California Forest and Range Experiment Station Miscellaneous Paper No. 15, June 1954, 9 pp., by A. E. Wieslander and Clark H. Gleason. Based on Forest Survey data, this paper defines woodland, chaparral, and associated types which pose problems in brushland management below California's commercial timber zone, and gives the acreage of each type.

"Teaching the Blind About Soil," in Soil Conservation **v.** 20, **n.** 1, August 1954, by Clark H. Gleason and Fred W. Herbert, tells how a group of blind boy scouts learned some fundamentals about soil and water, and qualified for the Soil and Water Conservation merit badge.

Manuscripts Accepted for Publication

"Detecting Hydrologic Effects of Changes in Watershed Condition by Double-Mass Analysis," by H. W. Anderson. To be published in Transactions, of A.G.U., Dec. 1954.

"Development of Vegetation after Fire in the Chamise-Chaparral of Southern California," by J. S. Horton and C. J. Kraebel. To be published in Ecology, April 1955.

"Rainfall Sampling on Rugged Terrain," by E. L. Hamilton. USDA Technical Bulletin No. 1096, Dec. 1954.

"Hydrologic Analysis Used to Determine Effects of Fire on Peak Discharge and Erosion Rates in Southern California Watersheds," by P. B. Rowe, C. M. Countryman, and H. C. Storey. To be multilithed as a California Forest and Range Experiment Station Report.

"A Guide to Erosion Prevention on National Forest Timber Sales," in the preparation of which Kraebel collaborated with N. F. Meadowcroft and others in the Regional Office, was completed for publication in multilith form by Region Five.

Manuscripts Submitted for Publication

"Temperature Requirements for Germination in Relation to Wildland Seeding," by W. C. Ashby and H. Hellmers, to Journal of Range Management.

"Streamflow Reactions of a Fire-Damaged Watershed," by J. D. Sinclair and E. L. Hamilton, to Hydraulics Division of the American Society of Civil Engineers.

Manuscripts in Preparation

"Root Systems of Some Chaparral Plants in Southern California," by H. Hellmers, J. S. Horton, G. Juhren, and M. O'Keefe, approved for submission to Ecology.

"Soil Fertility: A Watershed Management Problem in the San Gabriel Mountains of California," by H. Hellmers, J. F. Bonner, and J. M. Kelleher.

"Evidence of Nitrogen Fixation by Two Ceanothus Species," by H. Hellmers and J. M. Kelleher.

"Effect of Temperature and Photoperiod on the Growth and Flowering of Six Southern California Grasses," by W. C. Ashby and H. Hellmers.

"Reduction of Watershed Damages Incidental to Logging," planned as an article for the Journal of Forestry, and based on material prepared for the Regional Office timber sale logging "guide", is being written by C. J. Kraebel.

"Brushland Burning and Soil Erosion in Northern California," by Clark H. Gleason, is being reviewed by research and administrative officers of the Forest Service prior to its submission for publication.

Abstract has been submitted for a paper on "Reconnaissance Methods of Measuring Erosion" to be presented by Gleason at the General Geology Session, American Association for the Advancement of Science meeting in Berkeley on December 30.

CURRENT RESEARCH

SAN DIMAS EXPERIMENTAL FOREST

Rainfall

Rainfall for the 1953-54 hydrologic year totaled 24.92 inches at Tanbark Flat. This was 90 percent of the 25-year average of 27.72 inches for that gage. The October-December quarter was very deficient, with only 1.85 inch compared to 8.82 inches average. The January-March quarter was high, with 22.78 inches compared to 15.21 inches. The balance of the year was dry with 0.21 inches plus a few traces, compared to 3.43 inches average. Eight of the 13 storms had precipitation wholly or partly in the form of snow above 4,000 feet elevation.

Streamflow

Annual streamflow from watersheds within the Experimental Forest during the past year was less than 50 percent of the 14-year average. Storm peak discharges were moderate except for the debris-laden flood flows from watershed I which was 32 percent burned-over by the Barrett fire of December 1953. A number of streamflow analyses have been made to determine (a) the effects of this fire on peak flows and total storm discharges from burned and unburned watersheds, and (b) streamflow relations in undisturbed watersheds as a base for appraising the effects of cover treatment or chance denudation of these watersheds in the future.

Effects of the 1953 Fire

Effects of the 1953 fire on streamflow were described in CF&RES Technical Paper No. 6, March 1954, "Fire-Flood Sequences on the San Dimas Experimental Forest". Further analyses of the fire's effects on peak flow and total storm discharges were reported in the paper "Streamflow Reactions of a Fire-Damaged Watershed" by J. D. Sinclair and E. L. Hamilton (see above, Manuscripts Submitted for Publication). Highlights from these analyses are as follows:

The relation between peak flows before and after the fire was shown by double mass analysis of the runoff data from watershed I (partly burned) and watershed III (unburned). Accumulated peak flows from watershed I for 290 storms during 18 years were plotted over corresponding accumulated peak flows from watershed III. A line joining these plotted points maintained an average slope of 0.8 for 18 years, 1935-36 to 1952-53 inclusive. Then in January 1954 this relation changed abruptly when the slope of the line for the post-fire storms increased from 0.8 to 36.3 . Such a change is obviously significant.

The double-mass analysis included peak flows for all sizes and conditions of storms. A more specific basis for the determination of burn effects in watershed I was obtained by selecting a sample composed of pre-fire storms that produced peak flows ranging from 1/2 to 2 times the size of the peaks from watershed III, the control, after the fire. Further, the sample pre-fire storms were limited to those producing from 1/4 to 1-1/2 times as much rain as the post-fire storms. The peak flows from watershed I, partly burned, were plotted as ordinates over the peak flows from watershed III, unburned, as abscissas and a line was fitted to the points by the method of least squares. The equation for this line is:

$$I = -0.929 + 0.798\ III \qquad (1)$$

where I is the peak flow from watershed I in c.s.m., and III is the peak flow from watershed III in c.s.m. The standard error of estimate for the equation is 2.11.

If watershed I had not been damaged by fire, expected peak flows during the storms of January 17-20 and 24-25, 1954, computed by equation (1), would have been 3.36 and 10.46 c.s.m. respectively, a highly significant difference from the observed peaks of 429 and 297 c.s.m. These results indicate that the peak flow during the first storm was 128 times as great as, and during the second storm 28 times as great as expected had watershed I not been partially burned. The greater increase during the first storm was due in part to the flood wave that occurred.

Effects of the 1953 fire on total storm discharges from watershed I were determined by an analysis that included a series of 18 storms occurring during the 18 years of record before the fire. This sample of storms coincided generally with the storms used in the previous analysis of peak flows. Pre-fire storm discharges from watershed I were plotted over corresponding values for watershed III and a line was fitted to the points by the method of least squares. The equation for this line is:

$$I = 2.005 + 0.648\ III \qquad (2)$$

where I is the storm discharge from watersheds I and III is the storm discharge from watershed III, both discharges expressed in acre-feet per square mile. The standard error of estimate for the equation is 4.39.

Had watershed I not been partially burned the expected discharges during the two January storms, computed from Equation (2), would have been 6.09 and 10.95 acre-feet per square mile respectively. But observed discharges were 31.40 and 32.90 acre-feet per square mile. Thus the discharges from the fire-damaged watershed were 5.2 times as great as expected during the first large post-fire storm and 3.0 times as great as expected during the second large storm. These differences are significant at the 1 percent level.

Although storm discharges from the fire-damaged watershed were increased, the flows were bulked with unknown quantities of debris. Therefore the water content of the flows was less than indicated by records of total storm discharges.

Study of Streamflow Relations

Analysis of streamflow data from watersheds of the experimental forest is being continued to provide basic knowledge of storm discharge and water yield relations under the undisturbed conditions of the past several years. Such knowledge is needed as a basis for evaluating changes that may follow experimental treatments or chance watershed disturbances in the future. The Dalton watersheds (VII, IX, and X), for which 15 years of comparable records are available, have been selected for initial analysis.

Daily streamflow relations between watersheds vary widely throughout each year, as shown by regression analyses. Separation of each year's data into periods representing the three phases of the annual water storage cycle -- period of wetting, of sustained high moisture storage, and of drying -- greatly reduced these variations, and resulted in better correlations of streamflow between watersheds than when the period separation was not made.

Streamflow relations between watersheds also varied widely from year to year. These relations during years of heavy rainfall were different from those during years of light rainfall. The streamflow relations between watersheds were also influenced by amounts of rainfall during antecedent years.

The above variations in streamflow relations between watersheds appear to be of the kind caused by differences in soil and rock water storage capacities. In order to evaluate the effects of differences in water storage on streamflow, estimates of accumulated storage are being made by weekly intervals throughout each year. For this purpose storage is computed as being equal to: rainfall - (streamflow + interception loss + evapo-transpiration). Details of the analysis and results obtained will be reported when completed.

Rainfall Disposition

Tanbark Plots--Installation of the new brush runoff plots has been completed. Three stacks of soil moisture units were installed using the same depth locations as in the older runoff plots included in this study. The soil was of the same type and similar both in texture and depth to that of the older plots.

The vegetation on the Tanbark runoff plots converted to grass was sampled at the close of the growing season by the point transect system. There is a decrease this year in the cover density of the Italian ryegrass (*Lolium multiflorum*) and an increase in the density of red brome (*Bromus rubens*).

Cover densities for the 3 years are as follows:

Ground cover	Cover density (percent)		
	1952	1953	1954
Lolium multiflorum	33.2	53.1	26.4
Bromus rubens	3.2	4.4	13.7
Melica imperfecta	4.5	2.7	1.5
Other	20.8	3.0	1.6
Total vegetation cover	61.7	63.2	43.2
Oak leaf litter and duff	35.7	0	0
Dead stumps[1/]	1.1	0	2.1
Grass litter	0	0	41.1
Total litter, duff and stumps	36.8	0	43.2
Bare soil	1.5	36.8	13.6

1/ Values change because of variations in the line followed in the point transect system.

The brush was cut on the six plots between February 7 and 14, 1952. There were two sowings of Italian ryegrass that year -- one on February 19 and the other on April 7. Even so, the stand was spotty because of the large amount of oak litter on the soil surface. Most of the stump sprouts were killed in the summer of 1952 with 2,4,5-T.

The plots were burned for the first time on October 1, 1952, to remove the oak litter and the dead sprouts. The plots were resown on November 24, 1952. The ryegrass stand which developed was dense and vigorous and produced considerable litter cover for the following year.

LOS ANGELES RIVER WATERSHED

A summary of the work performed and findings to date in the cover improvement research program, Los Angeles River Watershed, is given in the accompanying progress report by H. W. Anderson and H. Hellmers, dated August 1954.

MEETINGS

April 2.--Hellmers gave the first talk in the spring series of Friday evening demonstration lectures at the California Institute of Technology. His topic was "Flood Prevention through Better Vegetation". The public was invited and approximately 150 were in attendance.

April 19.--Gleason spoke on "Watershed Management and Erosion Indicators" before the Conservation Class, San Jose State College. This class numbered about 60 regular students. Returning to Berkeley, he spoke on "Erosion, Runoff, and Cover-crops on Burned Areas of 1953 in Southern California"; this group was the San Francisco Bay Chapter, Soil Conservation Society of America. Some 25 members were in attendance.

April 20.--Hellmers presented the same material used in his April 2 lectures in a talk on "Vegetation and Flood Prevention" at the General Biology Seminar at California Institute of Technology. Twenty-five students and members of the Cal Tech staff attended this lecture.

May 3.--Sinclair, Kraebel, and Colman attended the California Station-Region 5 Annual Investigative Meeting at San Francisco. The program this year centered on the work of four divisions in the Experiment Station, namely Forest Management, Range Management, Watershed Management, and Fire Research. The report of each division included a summary of past work, current activities, and proposals for future research.

May 4.--Colman discussed "Watershed Management and Flood Control" before a meeting at Los Angeles of the Hydrology Section, Southern California Chapter, American Society of Civil Engineers.

May 19.--Gleason talked on "Indicators of Erosion on Watershed Land" at a meeting in Los Angeles of the Soil Mechanics Section, Southern California Chapter, American Society of Civil Engineers.

May 26.--Gleason spoke to the University of California Mothers' Club at Berkeley, on the subject "Water and Watershed Management". About 40 members attended.

June 3.--Rowe discussed "Problems of Watershed Management in the Mountain Areas of Los Angeles County" at a noon meeting of the Alhambra Chamber of Commerce, Governmental Affairs Committee. About 25 were present.

June 14.--Sinclair attended a meeting of the Conservation Committee of Los Angeles Chamber of Commerce.

June 21-25.--Hellmers attended the American Association for the Advancement of Science meetings at Pullman, Washington. He presented a paper entitled "Nitrogen Fixation by Ceanothus Species."

July 8-10.--Colman attended the R-5 Forest Service Advisory Council meeting on the Sierra National Forest.

July 13.--Gleason addressed the Conservation Class, San Jose State College on the subject "Water and Watershed Management in California". The 22 members of this class are mostly teachers in secondary schools.

July 16.--Kraebel talked to the Richmond, California Rotary Club on "Your Stake in California's Mountain Watersheds".

August 26-27.--Hellmers spoke on "Vegetation and Flood Control" at meetings of the Pasadena Kiwanis Club and at the Glendora Kiwanis Club. In all, some 150 heard the talks.

September 10.--Hamilton presented the paper "Streamflow Reactions of a Fire-Damaged Watershed" by J. D. Sinclair and E. L. Hamilton, at Austin, Texas, before the national meeting of the Hydraulics Division, American Society of Civil Engineers.

September 17.--Colman attended the Annual Meeting of the Associated Sportsmen of California in Stockton.

COOPERATION

American Geophysical Union.--A form report outlining research in soil moisture relations being carried on at the San Dimas Research Center was completed and returned to the Committee on Physics of Soil Moisture.

Angeles National Forest.--Anderson accompanied forest officers Gustaf Juhren and Rupert Pole, and Assistant County Forester Ezra Miller on an inspection of the Crescent, Maddock, and Monrovia Peak burns. The results of the emergency seeding of the first two burns to ryegrass and smilo, and the third burn to mustard and ryegrass were appraised as to survival, growth, and seed production.

California Division of Forestry.--A summary report of accomplishments on the San Dimas Experimental Forest during fiscal year 1954 and plans for fiscal year 1955 was prepared for the State Forester.

California Division of Water Resources.--Eugene D. Michael was given information on the geology of the San Dimas Experimental Forest for use in a preliminary survey of a route for the proposed Feather River Aqueduct south of the Experimental Forest.

California Institute of Technology.--David M. Wilson, graduate student in hydrology, was given descriptive material on watershed III, including a contour map and the necessary precipitation and streamflow data, for preparation of a term paper on construction of unit graphs of flood flows from records of storm precipitation.

City of Arcadia.--Frank Fisher, Engineering Department, Arcadia, was given estimates of maximum peak discharge frequencies for Lannon Canyon before and after fire. These estimates based on Fire Damage Appraisal data are to be used in determining drainage requirements for routing flows from this drainage through the city.

Columbia University, Department of Geology.--James C. Maxwell, graduate student in geomorphology is making a quantitative analysis of erosioned land forms in selected watersheds on the San Dimas Experimental Forest. He also plans to collect sufficient data for a hypsometric analysis (area-altitude analysis of erosioned topography) of these watersheds.

Bureau of Reclamation, Eureka Planning Section.--Anderson supplied suggestions for procedures to be used in the suspended sediment studies of the Section's resource review of the California north coastal area.

The Farm Management Magazine of Los Angeles was furnished material for a staff article on erosion and its control in mountain areas.

Hartford Insurance Company.--An adjuster for this company was furnished data on temperature, rain, and wind in Glendora for the period February 1-21, 1954.

Hawaii.--N. K. Carlson, land-use manager of the B. P. Bishop Estate (residual lands of the former royal family of Hawaii), conferred with Kraebel on forest land management problems, including (1) probable effects on water yield of logging the native koa and ohia forest, (2) possibilities of improving areas of non-commercial native cover by planting exotic tree species of high value. Plantations of Coast redwood, American ash, and other exotics started 25 and 30 years ago are now of merchantable size. Tests by the Forest Products Laboratory have shown Hawaiian-grown redwood to be equal in most respects to second-growth redwood from California, although the growth rate of the Hawaiian trees was much faster. Hawaiian-grown ash is to be similarly tested shortly. The prospects look good for the profitable growing of commercial timber crops in Hawaii on extensive areas of land now maintained in non-commercial native cover for the single purpose of watershed protection.

Japan.--Mr. Tohru Ishimitsu, Assistant Executive Secretary of the Resources Council in Tokyo, spent a half day in the Berkeley office to discuss problems of watershed improvement, especially soil stabilization in river headwaters, as an aid in flood control.

Los Angeles Examiner.--Mr. Wilson, photographer, was provided information for a pictorial article on the San Dimas lysimeter study.

Pasadena Star News.--Blythe Mendenhall, reporter, received information for two illustrated articles, one concerning the fire-flood sequence in Wolfskill watershed, and the other concerning rainfall disposition studies on plots and lysimeters at Tanbark Flat.

Rosecrans and Del Amo Foundations.--Spanish foresters Jose Nicolas and Fernando Gil were guided over the Sierra and Sequoia National Forests and Sequoia National Park by Hamilton.

San Bernardino National Forest.--Hellmers, at the request of Ranger Lloyd Hayes, made inspections and recommendations regarding the sowing of two recent burns in the Cajon District. It was recommended that the Cajon burn not be sown, but that the Lytle Creek burn be sown with a mixture of mustard and ryegrass.

The Southern California Air Pollution Foundation was supplied with cover type information to aid in a study of the effect of smog on vegetation in the Los Angeles River watershed.

Stanford University.--Bernard Corden, graduate student in Civil Engineering, was given rainfall-runoff data for watershed X, San Dimas Experimental Forest, for use in preparing a thesis on variations in the C constant of the "rational formula" ($Q = CiA$) for estimating flood flows from small streams.

University of California.--A manuscript "Litter and Forest Floor of Chaparral in Parts of the San Dimas Experimental Forest" by Dr. Joseph Kittredge, School of Forestry, was reviewed by Horton, Hellmers, and Rowe.

Rowe spent August 19 with Drs. H. H. Biswell, Arnold Schultz, and John Launchbaugh examining results of controlled burning on the forest floor and brush cover in ponderosa pine stands near Hoberg's Resort, Lake County, California. Methods of determining the effects of this type of burning on litter depths and physical properties of the surface soil were discussed.

With Extension Forester Metcalf, Kraebel presented a forestry demonstration August 31 at the California 4-H convention on the Davis campus of the University of California.

Vista Irrigation District.--Richard A. Smith, Assistant Engineer, was given reference material concerning influences of vegetation on water yield.

VISITORS

Visitors to the San Dimas Experimental Forest numbered 163 who came singly and in groups as large as 40 persons. From overseas came Bizan Yassamy, Iranian forester; Professor T. M. Tadros, ecologist from the University of Alexandria, Egypt; Miss Joan Whitmore, climatologist from the Union of South Africa; Prabhakar Madkao Dabadghao and Bubgounda Dergounda Patil, FAO Fellows from India; and Eng. Silvicultor Domingos Pereira Machado from Lisbon, Portugal. From American universities and colleges came Dr. Arthur N. Strahler of Columbia; Dr. Morrison of New York State College of Forestry; Prof. A. C. Ingersoll and 15 hydrology students from Cal Tech; Dr. D. A. Johanson, botanist from Pomona; Dr. Walter P. Taylor and 7 conservation students from Claremont; Dr. Willis E. Pequegnat and 28 students from Pomona; 19 soils students from the University of California; and 40 teachers studying conservation under the University of California Extension program. Twenty-five members of the Southern California Chapter, Soil Conservation Society of America, held their spring field meeting on the forest. And 16 administrative and research officers of the Forest Service and other government agencies, together with one newspaper reporter, rounded out the count.

At the Berkeley office notable visitors included Dr. George A. Garratt, Dean of the Yale School of Forestry, and seven of the Forest Service administrative and research personnel.

DISCUSSION BY H. W. ANDERSON OF KOVNER'S DEMONSTRATION OF THE APPLICABILITY OF GUMBEL'S THEORY TO THE RECURRENCE OF ANNUAL FLOOD PEAKS SEFES QUART. RPT. JAN.-MAR. 1953, PAGES C-5 to C-7.

The trial application of Gumbel's extreme value theory to annual flood frequency from Coweeta watershed No. 14 is interesting. Another method employing normal distribution theory has come into wide use lately (1, 2, 4). Since there are certain advantages to the normal distribution theory, the results obtained by applying this theory were compared with those Kovner reported.

Beard (4) reported recently that the logarithms of the flood flows were normally distributed for almost all of the 159 watersheds that he studied. A plotting of the flood flows for Coweeta watershed No. 14 (Table 3, C-6 op. cit.) indicated this was true also for that watershed. The mean flood flow is $\bar{0}.625$ and the standard deviation is $\pm$ 0.210 (both in log to the base 10 units). To obtain an estimate of the 100-year flood -- the flood of 0.01 probability -- we use the normal distribution theory which says that 0.01 of the floods will exceed the mean plus 2.326 times the standard deviation; so the 100-year flood equals $\bar{0}.625$ plus (2.326 times 0.210) or $\bar{1}.114$. Taking the antilog of $\bar{1}.114$ gives the 100-year flood as 130 c.s.m. This value agrees exactly with the Gumbel result.

Normal distribution theory can also give an estimate of the possible error in the estimate of the 100-year flood. The error variance is the sum of the variance of the calculated mean from the true mean and the variance of the calculated standard deviation from the true standard deviation. Beard's (4) equations 5, 6, and 7 can be combined to give the error of any estimated flood whose value is x standard deviation units from the mean as:

$$\delta x = \sqrt{(t^2S^2/n) + x^2S^2(1-(n-1)/\chi^2)^2}$$

Where: δx is the error of the estimated flood; t and χ^2 are the familiar tabular values for t and chi-square, n is the number of data, S is the standard deviation, and x is the number of standard deviation units that the flood is above or below the mean flood. Thus, using a probability of one chance in six, t = 1.0 and χ^2 = 11.5, with n = 18, and x (for the 0.01 flood) = 2.326, gives the error of the estimated flood as 0.117 log units, which is equivalent to 31 percent of the calculated 100-year flood. This error is about the same as the error indicated by the 0.68 confidence limit lines of Figure 1 (page C-7, op. cit.).

Some advantages of the normal distribution method are its ease of calculation and the fact that the frequency of floods may be fully characterized by only two numbers -- the mean and the standard deviation. With floods so simply characterized, studies of the relation of floods to watershed characteristics should make rapid progress (1, 3).

References:

(1) "Streamflow variability," by E. W. Lane and Kai Lei. Proc. Amer. Soc. Civil Engr., 1949, pp. 935-49.

(2) "A general formula for hydrologic frequency analysis," by Ven T. Chow, Trans. Amer. Geophys. Union 32(2), 1951, pp. 231-7.

(3) "Floods in Georgia, frequency and magnitude," by R. W. Carter. Geol. Survey Circ. 100, 1951, 127 pp.

(4) "Estimation of flood probabilities," by L. R. Beard. Proc. Amer. Soc. Civil Engr., 1954, Separate No. 438, 21 pp.

August 1954

PROGRESS REPORT

COVER IMPROVEMENT RESEARCH, LOS ANGELES RIVER WATERSHED

By H. W. Anderson and H. Hellmers
Division of Watershed Management Research
California Forest and Range Experiment Station

SUMMARY

Means are being sought to slow the movement of soil from the mountainous part of Los Angeles River watershed. The objectives of the research are to find out if, how and by how much soil movement can be reduced by vegetative means on steep slopes which are prevalent in this area. The work is being conducted by the California Forest and Range Experiment Station in cooperation with other local units of the Forest Service, the California Institute of Technology, and Los Angeles County Flood Control District.

This report summarizes the progress of research prior to fiscal year 1954, objectives and accomplishments for the fiscal year 1954, and plans for the current fiscal year. The work thus far has involved classification of mountain slopes as sources of sediment, the measurement of rates of soil movement on slopes of various classes under present vegetative cover, and studies of vegetation characteristics and requirements needed for the improvement of cover on mountain slopes. Future work will include testing the effectiveness of changed cover conditions in slowing soil movement from the slopes, and developing practical techniques for improving cover if and where changes in the vegetation are found to be effective.

Slopes have been classified based on steepness, north-south exposure, and proximity to ridges or to geologically downcut channels. Five study sites have been chosen, troughs to catch the material moving down-slope have been installed at each site and soil movement during one year has been measured.

Slopes above rejuvenated channels proved to have the highest rates of soil movement, and a south-rejuvenated slope had the highest of all. This south-rejuvenated slope produced material at a rate of 3,600 tons/sq.mi./yr., some 36 times the rate of the lowest producing site.

The dry season movement of soil by sliding and creep proved to be about half of the total yearly movement at the rejuvenated sites and ranged from 1/5 to 1/3 of the total movement at the non-rejuvenated sites. However, winter storms produced the highest short-term rates; the single storm of January 19-20, 1954 spewed sediment into one trough at a rate of 740 tons/sq. mi.

Each of the five study sites was separated into from two to six natural slope strips. Analysis of the first year's soil movement data indicates that if one or more of the natural strips were to be treated to improve the cover, with another strip maintained as a control, then treatments which reduced soil movement by a minimum of 17 to 21 percent could be detected on 19 to 1 odds at the rejuvenated sites.

Studies have shown that the growth of native shrubs can be stimulated by nitrogen for 2 to 3 years after application in the field. Stimulation of the vegetation by phosphorus was not significant in the field.

A method of testing the germination requirements of plants to be used for cover improvement was developed and 35 species of grasses and forbs were tested. Temperature requirements for growth of 14 native species and 22 exotic species were determined. Those that germinated and grew best under conditions similar to those on the local mountain slopes have been recommended for field trial prior to planting on the soil movement study sites. The recommended species include: Baccharis pilularis subspecies typica (prostrate form), Spartium junceum, Cytisus proliferus, Calycotome villosa, Eriogonum fasciculatum, Lotus scoparius, and Rhus laurina. The last three are native to the area.

Results obtained from this research program, particularly from the studies of vegetation, can be applied directly to the establishment or improvement of cover on road fills for soil stabilization. Steep and unstable road slopes are comparable to some natural mountain slopes where erosion is severe. Plants and techniques found to be superior for soil stabilization can be used on road fills as well as natural slopes.

Plans for fiscal year 1955 provide for the continuation of soil movement measurements at the present five study sites and for the establishment of additional sites on rejuvenated slopes that appear to be the principal sources of sediment. Emphasis will be placed upon preparing for publication the results of vegetation studies completed to date. It is planned also to test methods of establishing in the field the plants that have shown the most promise for cover improvement.

INTRODUCTION

Means of reducing soil movement by improving the vegetative cover on mountain slopes in Los Angeles River watershed are being investigated by the California Forest and Range Experiment Station. This work has been carried on in cooperation with other local units of the Forest Service, the California Institute of Technology and Los Angeles County Flood Control District.

A statement of the problems underlying slope stabilization work and a broad plan for cover improvement research in Los Angeles River watershed were included in a report of June 1950.1/ A more detailed plan for this research was set forth in another report of April 1953.2/ In the latter plan the research program was broken down into four kinds of studies as follows:

1/ "A Program for Cover Improvement Research in the Los Angeles River Watershed, Angeles National Forest," prepared by the California Forest and Range Experiment Station, June 6, 1950, 21 pp., typewritten.

2/ "Cover Improvement Research, Los Angeles River Watershed," prepared by Division of Forest Influences, California Forest and Range Experiment Station, April 4, 1953, 20 pp., typewritten.

Studies of soil movement designed to show where soil movement is active, the agents responsible for movement, the kinds of movement, and the rates and volumes of movement--all under vegetation as it exists now in various parts of the watershed.

Vegetation studies designed to determine the fertility levels of watershed soils and the response of native and exotic species to improved fertility, to determine the suitability of various native plants for soil stabilization, to select exotic plants that show promise as replacements for native vegetation, and to test the growth of promising exotic plants in the local soils and under local climatic conditions.

Soil movement studies under changed cover designed to determine if, how, and to what degree soil movement on slopes can be slowed by improving the native cover or by replacing it wholly or in part with exotic plants.

Techniques for improving cover to be developed if and where it is found that vegetation changes are effective in slowing the rate of soil movement.

Work thus far has been directed toward studies of soil movement and vegetation, the two initial phases of the research program. Integration of these studies in field tests will follow to determine the effectiveness of changes in the vegetation on soil stability.

This progress report includes a summary of work prior to fiscal year 1954, a review of objectives and accomplishments for fiscal year 1954, and plans for fiscal year 1955.

SUMMARY OF PROGRESS PRIOR TO FISCAL YEAR 1954

STUDIES OF SOIL MOVEMENT

An initial study of soil movement in Los Angeles River drainage was made by J. L. Retzer in the spring of 1951.3/ The study consisted of an inspection and mapping of 46 sample watersheds each 20 to 234 acres in area. Results of this work included a detailed description of the ways that soil moves in these watersheds, a listing of the apparent principal areas of movement, and a segregation of the watershed areas into 12 slope-exposure classes.

The study showed that in the watersheds mapped 59 percent of the slopes were steeper than 70 percent, 37 percent of the slopes were between 30 and 70 percent, and only 4 percent of the slopes were less than 30 percent.

3/ "The Origin and Movement of Sediments in the Los Angeles River Watershed, California," by J. L. Retzer et al., July 1952, 103 pp., typewritten.

The main areas of soil movement, listed in decreasing order of importance as sediment sources were found to be:

Stream sides and slopes adjacent to geologically rejuvenated channels
Steep slopes with southern exposure
Very steep upland slopes of other exposures
Fault zones and steep fault faces
Deep colluvial-alluvial deposits of upland slopes undercut by roads and streams

Retzer's work was a reconnaissance of the soil movement problem. The study was not designed to furnish quantitative information on rates of movement.

In September 1952, O. C. Olson started work on the problem of determining rates of soil movement. By early summer, 1953, five study sites on slopes had been chosen and equipped with troughs to collect material moving down-slope. The sites were chosen where the brush had been long unburned, where the geology was classed as predominately Wilson diorite, and where there were no disturbances due to roads or other clearing. Sites were chosen with contrasts in exposure (north slopes versus south slopes) and contrasts in the degree of geologic rejuvenation. At each site a half-round steel trough was inserted flush with the soil surface on contour from the point of a ridge to a stream channel.4/ The troughs range in length from 68 to 431 feet, sampling a wide range of slopes. At one extreme are the low-gradient slopes near rounded ridges. At the other extreme are slopes whose gradient exceeds the angle of repose. The physical characteristics of the five study sites are summarized in Table I.

STUDIES OF VEGETATION

Studies concerning the plant physiological aspects of cover improvement were started in 1948 by E. C. Stone. The work was conducted in cooperation with Professors James F. Bonner and F. W. Went of the California Institute of Technology and personnel of the Angeles National Forest and the Forest Service Soils Laboratory at Arcadia. Means were sought to stimulate the germination of certain native shrubs including chamise (Adenostoma fasciculatum) and sugar-bush (Rhus ovata). An attempt also was made to develop methods of recognizing nutritional deficiencies from ash analyses of plants grown in local mountain soils.

In the fall of 1949, H. Hellmers, with the cooperation of Professor Bonner, began an investigation of the nutritional status of soil derived from three major geologic formations found in Los Angeles River drainage, namely Wilson diorite, Lowe granodiorite, and anorthosite. This work was conducted in the greenhouses of the Institute. The study was concluded in 1952. On the basis of results obtained with five native plant species, the following nutritional characteristics were found to be common to the three soil materials tested:

4/ "Development of Sediment Collection Troughs, Soil Movement Study, Los Angeles River Watershed, California," by O. C. Olson, August 17, 1953, 4 pp., typewritten.

Table 1.--Characteristics of soil movement study sites

Site characteristics	Site name				
	Lower Brown	Upper Brown	Falls	Singing Springs No. 1	Singing Springs No. 2
Trough length, feet	68	273	431	291	200
Area above trough, acres	0.72	0.82	1.27	1.44	1.64
Exposure	South	South	North	South	North
Geologically rejuvenated	Yes	No	Yes	No	No
Steepness of slope, %	60-120+	30-75	30-100+	45-65	45-75
Elevation, feet	2,500	3,400	2,750	3,400	3,410
Dominant cover	Chamise Mahogany Manzanita	Manzanita Oak	Oak Bay Manzanita	Chamise	Chamise

Nitrogen is deficient and this condition is highly limiting to plant growth.
Phosphorus is deficient but it is limiting to plant growth only after the nitrogen deficiency has been satisfied.
Calcium and potassium contents of the soils are sufficient, so far as the native plants tested are concerned.
The content of micro-elements (including molybdenum, zinc, copper, boron, and magnesium) probably do not limit native plant growth.

Fertilizer tests in the field were started during 1951 to determine whether the nitrogen and phosphorus deficiencies found in the greenhouse limit the growth of native plants in the local mountains. Plant growth on treated and untreated plots was compared. Treatments consisted of additions of 100 pounds of nitrogen per acre, 100 pounds of phosphorus per acre, and 100 pounds each of nitrogen and phosphorus per acre. Three years' results from eight plots showed that plant growth was increased by the application of nitrogen even in the exceptionally dry year of 1950-51. A significant growth response to the one nitrogen application was obtained for 2 to 3 years following fertilization, indicating a holdover effect. Phosphorus, either alone or in addition to nitrogen, failed to give an added response to plant growth in the field.

A detailed field study of the root systems of 18 species of native plants was made in 1951 by G. Juhren and J. O'Keefe. The roots of 76 plants were excavated hydraulically and the root systems of others were examined where exposed in road cuts. The plants were classified as being deep- or shallow-rooted, and various characteristics of the root systems were described. All deep-rooted species had a high concentration of roots in the upper layer of soil. Some species had root systems that penetrated the fractured rock to depths of more than twenty feet. All plants studied had a wider spread of roots than crown which confirms earlier ideas that the soil in openings in the brush canopy is usually occupied by roots.

In 1951 B. W. Heacox made a review of available literature and visited California arboreta, herbaria, nurseries, and estates searching for species that might be suitable for cover improvement work. In his report of this investigation, Heacox listed 85 likely non-native species.5/ Twenty-eight of these species were recommended by J. S. Horton for further investigation.

During 1952 H. Hellmers, with the help of Professor F. W. Went of the California Institute of Technology, established contacts with workers in regions of Mediterranean-type climate throughout the world to obtain seed of desirable exotic plants. The seed of 30 species were obtained in this way from 12 foreign countries. At the same time W. C. Ashby was developing laboratory methods to screen these exotic plants by testing under controlled conditions, their physiological responses to local variations in temperature, moisture supply, and soil.

5/ "Plant Search Project" by B. W. Heacox, September 1951, 46 pp., typewritten.

A method of testing the germination requirements of plants to be used for soil stabilization was developed, utilizing the facilities of the Earhart Plant Research Laboratory at the California Institute of Technology. Some 35 species of grasses and forbs were tested and found to have wide variability in requirements for germination. This work pointed out the necessity of knowing the ability of the seed of a species to germinate under field conditions in order to select the best species and sowing date for a particular locality.

A test of the growth responses to temperature of 14 native species of grasses and shrubs also was completed in the Earhart Laboratory. The results showed that growth under controlled temperatures chosen to simulate local seasons of the year correlated well with the growth of native plants in the field on the San Dimas Experimental Forest. These results and field correlations made it possible to establish a short-term growth test for exotic species. By using a 6-month test in the laboratory several years of field planting and testing were avoided. Testing of 22 exotic species was started, 10 were completed by the end of fiscal year 1953.

Preliminary work was done to develop a test of the ability of plants to withstand drought. This work showed that the rate of water loss from a plant, and the ability of a plant to go dormant when subjected to water stress, are two of the factors that determine the drought resistance in native species.

Native species showed differences in growth rates when grown in the greenhouse on soils taken from the three major geologic types: Wilson diorite, Lowe granodiorite, and anorthosite. Tests were started to determine the ability of several promising exotic species to grow on these soils.

OBJECTIVES FOR FISCAL YEAR 1954

STUDIES OF SOIL MOVEMENT

The objectives as originally outlined for this year[6/] were: (1) to determine the amount and character of the material caught in the troughs at the five study sites, and (2) to study the variations in the catches with differences in (a) slope types, (b) agent responsible for movement (gravity versus water), and (c) season of the year. Additional objectives were set up in January 1954, after considerable data had become available. These objectives were: (3) to test the relation between soil movement rates from

---

6/ "Work Plan for Quantitative Study of the Surface Movements of Sediments on Mountain Slopes, Los Angeles River Watershed, California," by O. C. Olson, August 19, 1953, 5 pp., typewritten.

"natural slope strips"7/ and the length, area, and other characteristics of the slope strips, (4) to test the degree of correlation between the periodic catches from strip to strip at the same site as a means of estimating the minimum cover improvement effect that could be detected if a strip were to be treated, and (5) to supplement the measurements of material caught with measurements of leaf-fall, rainfall, and soil moisture.

STUDIES OF VEGETATION

The vegetative phase of the program was reduced and slightly altered during fiscal year 1954 as compared to plans outlined in the 1953 report2/ because of insufficient funds. The proposed field study to determine the optimum application level for nitrogen was not undertaken. Neither were there any new species introduced into the study of growth characteristics of exotic species. Special emphasis was placed on completing studies, analyzing data, and the preparation of publications.

ACCOMPLISHMENTS DURING FISCAL YEAR 1954

STUDIES OF SOIL MOVEMENT

Material moving into the troughs was collected by 20-foot segments of trough length at each of the five study sites. Collections were made at approximately monthly intervals at all sites except Lower Brown, where approximately weekly collections were made. In all, 831 catches of material were collected. They ranged in weight from a few grams of sand and leaves to as much as a half ton of rocks, soil, and organic matter. Small catches were brought in from the field in toto; large catches were weighed in the field, sampled, and the sample brought in to the laboratory for processing.

The field samples of material caught in the trough at each study site were processed to determine oven-dry weights and proportions of organic vs. inorganic matter. After air-drying and re-weighing, the material from each sample was passed through a swing-hammer mill. Homogenizing the material in this way permitted splitting the sample into sub-samples that could be analyzed. Moisture content was obtained by drying a sub-sample in an oven for 24 hours at 105° C; organic content was obtained by ignition of a sub-sample at 550° C. All catches up to and including that of June 8, 1954 have been processed for moisture and organic content.

Field weights of all samples taken during the year were corrected for moisture content. Catches were compiled by whole study sites, by natural slope strips within sites, by seasons and by periods within seasons.

7/ A "natural slope strip" is a segment of a slope at a study site bounded by topographic ridges at the two sides and the top and by the catchment trough at the bottom.

Analyses were made of the relation of sediment catch from natural slope strips to strip lengths and areas. A calibration analysis and report[8] were made of the natural slope strips to determine the minimum treatment effect that could be detected if one or more of the strips at each site were treated and other strips used as controls.

Standard rain gages were installed in openings in the vegetation near each of the study sites. The gages were read after each major storm or when the material from the troughs was collected. Amounts of soil movement during the winter are expected to be related to rainfall.

Soil moisture sampling was initiated on March 2, 1954. Samples were taken to a depth of 3 inches of soil under a high canopy of bay and maple trees near the Lower Brown study site. Duplicate samples were taken at about weekly intervals in soil bare of litter, under 3/4 inch of litter, and under 2 inches of litter. Rates of soil movement by sliding are expected to be related to soil moisture. If soil movement can be related to rainfall and soil moisture these relations will permit calculation of mean annual soil movement from the study sites.

Some characteristics of the areas immediately above the troughs were inventoried by 20-foot segments along the troughs. At each site the inventory included: (1) whether the segment was a swale, a ridge, or a plane slope; (2) the slope of the surface in percent for horizontal distances of 0-6 and 0-20 feet above the trough; and (3) the cover density in the strip 0-6 feet above the trough. At the Falls site the amount of bare surface by 3-foot strips for a horizontal distance of 9 feet above the trough was inventoried; at the Upper Brown site the amount of bare soil, the size and number of exposed rocks, and the size and number of brush stems were inventoried. These data will be used to determine changes in the sites with time and to test the correlation of the amount of soil movement with site characteristics.

Aerial photos were taken of each of the sites. Enlargements to a scale of 1 : 2,000 and 1 : 500 were made to serve as work maps of the study areas. Ground photos were taken of the sites from opposite slopes, of typical ridge and swale segments near the troughs, of the troughs, and of typical catches of material in the troughs.

Collection boxes were installed to permit estimation of the amount of organic matter caught in the troughs by direct leaf-fall at each study site. Eighteen boxes were placed under typical brush and tree types so as to include a range of vegetation cover densities. Collections from the boxes have been made periodically. Direct leaf-fall will be subtracted from the total organic catch in the troughs.

8/ "File Report, Calibration of Soil Movement Study Sites, Based on First Year's Records," by H. W. Anderson, April 26, 1954, 10 pp., typewritten.

Minor improvements to the installations were made including the installation of 12-inch baffle boards on the Lower Brown trough where rolling rocks might leap the trough, the repair of two sections where the trough lip did not properly meet the soil surface, and the painting of a "creep" line 1 inch from the upper edge of the concrete lip of each trough so that the soil accumulating on the lip could be removed quickly and consistently at each collection.

Results

Amounts of material moving into the troughs at each of the study sites during four seasons (dry season, wetting season, wet season, and drying season) and the total amounts from July 16, 1953 to June 1, 1954 are summarized in Table 2.

Dry season movement of material amounted to about half the total movement at the rejuvenated sites, and ranged from one-fifth to one-third of the total movement at the non-rejuvenated sites. Total movement of material was higher at the rejuvenated sites than at the non-rejuvenated sites. Movement was highest at the south rejuvenated site, equivalent to 3,600 tons/sq. mi./yr., some 36 times that at the lowest, the north non-rejuvenated site. Additional data will be required to determine mean soil movement by seasons and long-term mean annual soil movement for the different classes of sites.

The kinds of material moving down the slopes into the troughs were highly variable from site to site. Catches at the Upper Brown site ranged from 43 to 46 percent organic, mostly leaves and twigs; whereas catches at the Lower Brown site were only 2 to 15 percent organic. At all sites except Lower Brown, practically all of the material consisted of fines and organic matter. At the Lower Brown site some 12 percent of the material was rock with diameters greater than 4.5 inches, the largest rock weighing 156 pounds.

The following information on soil movement processes during different seasons was obtained by observations at the study sites.

Dry season movement at all sites was largely due to sliding and creep, augmented by small animal and deer activity.

Wetting season movement was low. Following the first fall rains movement processes changed. Sliding of the fine material practically ceased as the moisture gave some degree of cohesion to the soil. However, at the Lower Brown site the moisture loosened some large rocks ranging in diameter from 5 to 15 inches which rolled into the trough. Small animal activity and minor amounts of soil splash accounted for the remaining movement of sediment from the slopes during the wetting season. From the start of the fall rains throughout the winter and until the soil dried out in the late spring, soil movement by sliding was slight.

Table 2.--Catches of material[1/] from soil movement study sites

Period of delivery	Site				
	Lower Brown (south[2/] rej.[3/])	Upper Brown (south non-rej.)	Falls (north rej.)	Singing Springs No. 1 (south non-rej.)	Singing Springs No. 2 (north non-rej.)
	Tons/acre				
Dry season July 16-Nov. 14, 1953	2.13	0.15	0.30	0.03	0.05
Wetting season Nov. 15, 1953-Jan. 11, 1954	0.24	0.09	0.12	0.02	0.04
Wet season Jan. 12-Mar. 31, 1954	2.57	0.11	0.13	0.07	0.03
Drying season Apr.1-June 1, 1954	0.07	0.09	0.03	0.03	0.02
Total	5.01	0.44	0.58	0.15	0.14
Relative rate of delivery	36	3	4	1	1

1/ Organic plus inorganic, uncorrected for small amounts of direct leaf fall into the troughs.
2/ Exposure of slope.
3/ Geologically rejuvenated or non-rejuvenated.

Wet season movement at all sites except Lower Brown appeared to be caused largely by raindrop splash and local rilling of bare surfaces. At the Lower Brown site, splash was also active, but most of the soil was moved into the trough by surface flows. These flows, concentrating from impervious rock and shallow soil areas, picked up a load of sediment from the minor channels and from the colluvial soil, and spewed the material into the trough. In the January 19-20, 1954 storm alone some 1,670 pounds of soil moved into the trough at the Lower Brown site.

Drying season movement was least of all. A crust on the soil formed by the beating rains during the winter practically eliminated sliding. The spring rains were too light to cause any surface runoff or very great splash and practically no large rocks were released. There is evidence that crusting of the surface soil and resulting soil stability are transitory. As the soil dries out any disturbance tends to initiate soil sliding. Observations indicate that when these areas are treated the least disturbance would be done if treatment was applied in the fall or winter. Disturbances in the spring would probably initiate early sliding of soil.

That changes in the rates of sediment production are controlled by the amounts and occurrence of rainfall is most strikingly illustrated by data from the Lower Brown site (Figure 1). Here during the year 1953-54 the movement of material in the dry and in the wet seasons was approximately equal. The wetting season movement was small despite the persistence of this season into January. The drying season movement was even smaller than the wetting season movement. The other sites showed similar trends but somewhat different proportions (Table 2).

Studies were made of the relation of the catch of material from the individual slope strips at each site to characteristics of the contributing slopes. During the dry season the trough catch at the Falls site was found to increase uniformly as the slope length increased. At the Brown site, in contrast, the variation in catch was independent of length of the slope. This difference suggests that soil moved in a different manner at the two sites. On the rejuvenated slopes of the Falls site the soil moved as a cumulating stream down the slope length. On the less steep slopes of the non-rejuvenated Brown site the soil moved uniformly, step-by-step, and only material from the bottom step reached the trough. Further study of the processes by which soil moves down the slopes will help explain differences in rates of soil movement and should be useful in evaluating cover treatment effects upon soil movement.

In the evaluation of cover improvement the general plan is to treat the vegetation on one or more parts of a study site, using an untreated part as a control. Preliminary to any treatment a calibration analysis is needed to determine what magnitude of treatment effects can be detected. Using the covariance analysis method outlined and illustrated by Wilm[9] an analysis was made of the first year's soil movement records from the study sites.

9/ "How Long Should Experimental Watersheds be Calibrated?" by H. G. Wilm, Trans. Amer. Geophys. Union, v. 30, pp. 272-8, 1949.

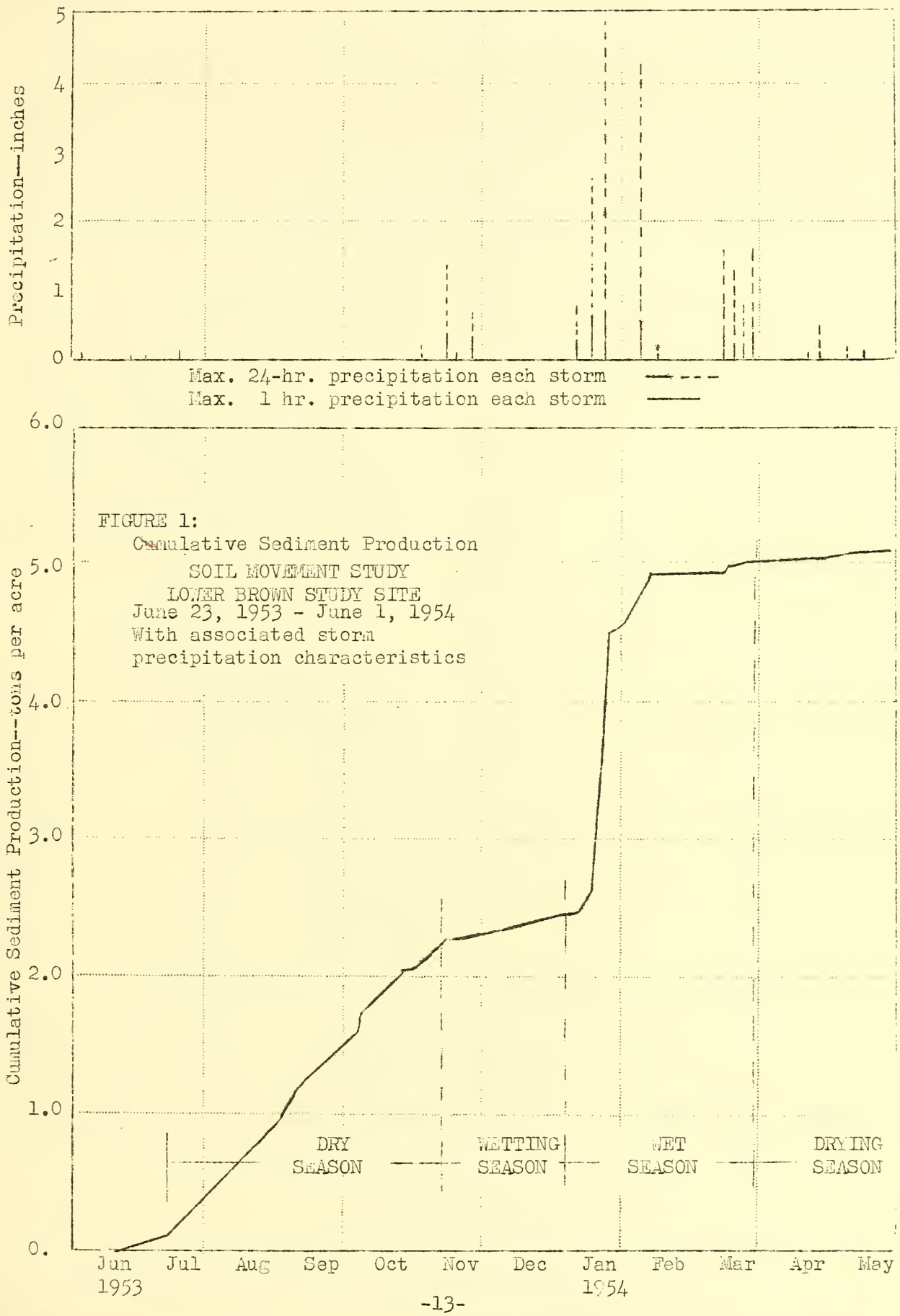


FIGURE 1:
Cumulative Sediment Production
SOIL MOVEMENT STUDY
LOWER BROWN STUDY SITE
June 23, 1953 - June 1, 1954
With associated storm
precipitation characteristics

Each study site was segregated into from 2 to 6 natural slope strips.7/ From the degree of relationship between the periodic catches among strips, the minimum detectable treatment effect at each of ten possible treatment strips was calculated. For strips at the rejuvenated sites, it was found that treatments which affected the mean yearly catch by a minimum of 17 to 21 percent could be detected on 19 to 1 odds. For strips at the other sites treatment effects ranging from 20 to 43 percent would be needed to be detectable.

This calibration analysis was made to determine the magnitude of treatment effects that could be detected based upon one year's records of soil movement from the slope strips. The method of study appears to be adequate although additional records of soil movement are needed to detect treatment effects under a wider range of climatic conditions.

Personnel

The soil movement studies were carried on during the year by two technical men working a total of 12 man-months and two assistants a total of about 10 man-months. In addition, technical and clerical assistance as needed was provided from the Experiment Station.

STUDIES OF VEGETATION

Work was completed on the nutritional study of soils from Los Angeles River watershed. This included a greenhouse test with annual (Italian) ryegrass, Lolium multiflorum. The total dry weight and number of tillers per plant of this grass were approximately doubled by the addition of nitrogen (100 lbs./acre) to anorthosite, Lowe granodiorite, and Wilson diorite parent materials. Additions of nitrogen and phosphorus (100 lbs./acre/element) together further increased the size and number of tillers per grass plant. Potassium, calcium, manganese, zinc, copper, boron, and molybdenum appeared to be present in the soils in sufficient quantity for a good growth of grass. Thus it appears evident that the growth of annual grass can be increased on subsoil sites in Los Angeles River watershed by the application of fertilizer. Nitrogen at 100 lbs./acre should provide good growth. Nitrogen plus phosphorus at 100 lbs. each/acre will further stimulate growth if water is available.

The Ceanothus leucodermis and C. crassifolius plants that had previously been planted in nitrogen-deficient soil were harvested and the data analyzed. Both species, when associated with their nodule forming organism, were found to be capable of fixing atmospheric nitrogen. By fixing nitrogen these plants improved the quality of the soil for their own and for other plant growth. This finding indicates that these species are valuable components of the vegetation on the nitrogen-deficient soils of Los Angeles River watershed.

Twelve additional recommended exotic species were tested for their ability to grow under the climatic conditions that occur in the San Gabriel Mountains. These tests, like the previous ones, were conducted in the temperature-controlled greenhouses of the Earhart Plant Research Laboratory. Data on all of the 22 exotic species grown to date were analyzed. Four of the species appeared to have superior qualities for cover improvement in local mountain areas. One of these species, Baccharis pilularis subspecies typica, is prostrate, roots at the nodes, and is capable of good growth under the local climatic conditions. Thus it forms a good mat of vegetation directly on the soil surface. The other three species are nodulated legumes. From a soil-binding standpoint these leguminous species have no advantage over the native species but they could be used in a planting program as a long-time source of nitrogen. From a nitrogen-fixing standpoint they have the advantage of growing more rapidly than the Ceanothus species. The three recommended legumes are Calycotome villosa, Cytisus proliferus, and Spartium junceum, all from the Mediterranean area. The other species tested were eliminated for their lack of ability to grow well during the seasons when soil moisture is available, or to survive the summer heat or winter cold in the local mountains.

Supplementing the growth studies in the laboratory, 33 species (hybrids, or geographical strains of exotic species) were planted in field plots for positive identification and field observation. The hybrids used were crosses of prostrate and drought-resistant species of Ceanothus.

Information obtained from the studies of vegetation can be applied in the establishment or improvement of cover on road fills for soil stabilization. Steep and unstable road slopes are comparable to some natural mountain slopes where erosion is severe. Thus plants found to be superior for soil stabilization can be used on both road fills and natural slopes.

The nutritional study of soils from Los Angeles River watershed also has shown that the growth of plants on subsoil sites such as road fills can be increased by the application of nitrogen.

Reports

Some results of the vegetation studies have been published. Other findings are being prepared for publication. The title and present status of each paper is as follows:

"A rapid method of separating seed of chamise (Adenostoma fasciculatum) from the duff" by E. C. Stone and J. Holt. Ecology 31(1): 149. January 1950.

"Water absorption from the atmosphere by plants growing in dry soil" by E. C. Stone, F. W. Went, and C. L. Young. Science 111(2890): 546-548. May 19, 1950.

"The effect of fire on the germination of the seed of Rhus ovata Wats." by E. C. Stone and G. Juhren. Amer. Jour. Bot. 38(5): 368-372. May 1951.

"Temperature requirements for germination in relation to wild-land seeding" by W. C. Ashby and Henry Hellmers--submitted to the Journal of Range Management for publication.

"Root systems of some chaparral plants in southern California" by H. Hellmers, J. S. Horton, G. Juhren, and J. O'Keefe--completed for submission to Ecology.

"Soil fertility: a watershed management problem in the San Gabriel Mountains of California" by H. Hellmers, J. Bonner, and J. M. Kelleher--in final review before submission to Soil Science.

"Growth of grasses in relation to day and night temperature conditions" by W. C. Ashby and H. Hellmers--data computed and first draft completed.

"Evidence of nitrogen fixation by two ceanothus species" by H. Hellmers and J. M. Kelleher--first draft being prepared.

"Growth of shrub species in relation to day and night temperature conditions" by H. Hellmers and W. C. Ashby--data computed and publication plan being written.

Personnel

The vegetation studies were conducted by a plant physiologist and an assistant working full-time during the fiscal year. In addition, technical and clerical help as needed was provided by the Experiment Station.

PLANS FOR FISCAL YEAR 1955

The program for cover improvement research prepared in 1953[2/] is still applicable. However, plans for the current fiscal year are based upon a reduced budget of $20,000. These plans are aimed at producing the maximum benefits from the studies of previous years. Listed in the order of priority the plans are as follows:

STUDIES OF SOIL MOVEMENT

1. Measurements of soil movement at the present five study sites will be continued as well as the determination of the oven-dry weight and organic content of the materials collected from the study sites. Collections of material will be made by the natural slope strips rather than by 20-foot segments of catchment trough used previously. Supplemental measurements of rainfall, soil moisture and leaf fall will also be made.

2. An additional study site to provide at least three more slope strips will be established on a south-rejuvenated slope to replicate measurements where soil movement appears to be greatest. If possible, catchment troughs will be installed and measurements started before the fall storms of 1954.

3. A study of the rates of movement of soil and litter particles over the surface of various slope classes will be started using marked particles or simulated soil and litter particles. This technique will be used to test the hypothesis that the place where rejuvenated slopes meet the non-rejuvenated slopes and the place where the channels meet the rejuvenated slopes are the primitive sources of soil instability--the places where movement originates and is perpetuated. To the degree that this is true it may be possible to further localize treatment for the control of soil movement.

4. An additional study site will be established on a north-rejuvenated slope. A site is needed with longer length of slope than occurs at the present Falls site.

5. Recalibration of the study sites to test what minimum cover improvement effects could be detected after next year's measurements of soil movement become available will be made in the spring of 1955.

STUDIES OF VEGETATION

1. Reports now in progress concerning the results of vegetation studies obtained to date will be completed for publication as rapidly as possible. The proposed publications are listed on page 16 of this report.

2. Emphasis will be placed on developing methods to establish in the field the plants recommended for soil stabilization. Before planting any of these species on the soil movement study sites a reasonable chance of good establishment and growth should be assured. When winter rains occur, establishment of the plants will be attempted on a rapidly eroding south slope comparable to the Lower Brown study site.

Seven species (100 plants/species) will be tested: namely, Baccharis pilularis subspecies typica (prostrate form), Spartium junceum, Cytisus proliferus, Calycotome villosa, Eriogonum fasciculatum, Lotus scoparius and Rhus laurina. Both transplant and direct seeding methods of plant establishment will be used.

Previous studies have shown two factors that must be considered in testing plants in the field. First, the present vegetation, sparse as it may be, will have to be killed to prevent competition for moisture. Roots of the existing vegetation are known to occupy the soil in the bare areas between plants and would thus prevent the establishment of other plants in these areas. Second, the seed or plants will have to be protected from rodents and deer in the area. This will be accomplished, if possible, with wire mesh barrier around individual plants or groups of plants rather than by fencing the steep slopes. Half of the plants will be fertilized with nitrogen.

PERSONNEL

Studies of soil movement planned for the current year will be conducted by a soils scientist and an assistant each working half-time. Studies of vegetation will be carried on by a plant physiologist working full-time and an assistant half-time. In addition, technical and clerical assistance as needed will be provided by the Experiment Station.

SEMIANNUAL REPORT ON FOREST INFLUENCES

Central States Forest Experiment Station

Athens Research Center

April 1954 -- September 1954

General

Most of this summer has been spent in the field taking data on established projects including a study of the soil-site relationships of various hardwood species of southeastern Ohio.

The extended drought discussed in the last semiannual report continued through July. In August the drought was finally broken by rainfall in excess of the expected average for the month. This marked the first month since May, 1953, that precipitation exceeded the expected monthly average.

Meetings

In April, Carmean presented a paper entitled "Structure of Forest Soils" at the annual meeting of the Conservation Section of the Ohio Academy of Science.

This spring Merz, Finn, and Carmean visited the Fernow Experimental Forest at Parsons, West Virginia where watershed and forest management installations and techniques were observed. In June, Carmean visited the Plum Creek Pilot Watershed developed by the Soil Conservation Service in Kentucky.

In August, Carmean instructed Forest Watershed Management at the Annual Ohio Forestry Association Training Camp. This camp is held for the purpose of training youths of Ohio in the rudiments of forestry and conservation.

Publications and Manuscripts

"Structure of forest soils," by W. H. Carmean, has been submitted to the Ohio Journal of Science.

Conversion of poor-site hardwood ridges to pine

This study, described in detail in the last semi-annual report, consists of clear-cutting poor-site-oak stands and planting pitch, shortleaf, and white pines. As a supplement to the silvicultural phases of this project, a study is being made on the effects of clearcutting on soil moisture, surface-water runoff, and soil and humus development. Preliminary results after 5 months of observation indicate that:

(a) Except for a few skid trails, the surface soil and surface organic layers on the clearcut plots were not seriously disturbed by the mechanics of logging. Samples of L(litter), F(fermentation), and H(humus) layers were gathered during September. Results indicate that, approximately 8 months after clear-cutting, the F and H layers are not materially different from these same layers in nearby undisturbed forest areas. The L layer, however, is greatly reduced in the clear-cut area. This reduction may have resulted from a more rapid rate of decomposition caused by increased insolation and higher soil moisture conditions. Increased wind movement may also be partially responsible for the reduced L layer.

(b) Weekly soil moisture samples of the A, B, and C horizons are being taken by means of a King tube. Results show a much higher soil moisture content in the clearcut area than in adjacent undisturbed forest areas. This difference is most pronounced in the A horizon and least pronounced in the C horizon. The drastic reduction in transpiration caused by clear-cutting is thought to be responsible for the high moisture content in the clear-cut areas. Despite the increase in solar insolation in the clear-cut area the soil moisture remained high in all horizons indicating that the water loss due to evaporation was small in comparison to that lost by transpiration. The mulching effect of the surface organic layers may have contributed to the slow rate of evaporation.

(c) Surface water runoff is being measured by runoff troughs located in the clearcut plots and in nearby undisturbed forest conditions. At present, data are available on runoff from 12 storms ranging from 0.14 to more than 4.0 inches in total rainfall. The runoff from these plots probably represents surface water and subsurface storm flow moving through the surface organic layers and the top inch of surface soil. This belief is supported by the observation that the runoff water contains little suspended sediment.

Results to date indicate that large increases in runoff occur as the quantity of rainfall increases. When the rainfall was about 1.5 inches more than 29 times as much runoff was obtained on the clearcut plots as when the storm was less than 0.5 inches. For undisturbed forest areas the ratio was somewhat less. For all storms about four to five times more runoff was obtained from the clearcut area than from the undisturbed forest areas. We believe there are at least two reasons for this difference: (1) there is virtually no interception of precipitation in the clearcut plots, and (2) the soils in the clearcut plots have a higher moisture content. The soils within all the runoff installations have shallow A horizons, contain a lot of clay, and have plastic subsoils. Soils having these characteristics swell when moist and probably greatly retard infiltration rates causing an increase in runoff.

The above qualitative observations are quite evident in the initial data from these clear-cut plots. Before definite conclusions are reached, however, a much longer period of observation is necessary and the data must be tested for possible relationships with such things as days since rainfall and rainfall intensity.

Relationship between oak site quality and the soil and topographic features of southeastern Ohio

This study was begun in June and will be a long-term study that will eventually include all the species of oak important in Ohio. Yellow-poplar, hickory, pitch and Virginia pine may also be studied in the future.

Twenty-two plots were established during the summer with major emphasis being given to black oak. A detailed analysis of understory shrubs and herbs is being made as well as measurements of soil and topographic features. Data on understory species may eventually be used to develop a method of site evaluation based on plant indicators. Data from the first 22 plots indicate that good site for black oak is associated with deep A horizons and with well aerated loams and sandy loams. Better sites are also found on lower slopes and in coves. Because topography effects on site are confounded with the depth of A horizon, more study is needed before a definite independent relationship can be established.

Future Plans

Two watersheds on the Vinton Furnace Experimental Forest have been equipped with concrete and brick sills for expediting the collection of water samples. The sediment content of the water from these watersheds will be measured for about 1 year. Samples are collected at weekly intervals and, when possible, during storm periods. After the average sediment content under undisturbed conditions has been established, one watershed will be completely clearcut and the other will be cut using a modification of the group selection methods. Approved methods of road and skid trail location and construction will be used on both watersheds. Water samples will be taken during and after logging to determine the effects of the cutting and logging on water turbidity.

A third watershed will be equipped with a weir and a water level recorder. This watershed will be maintained in an undisturbed condition to provide basic data on the yield and periodicity of water flow from small forested watersheds in southeastern Ohio.

An analysis of the problems in watershed management in the Athens Research area is now being written. The nature, extent, and importance of the problems will be considered as well as a suggested program of research for the study of these problems. A brief report, however, has been completed which outlines the major forest watershed problems and a suggested program of forest watershed research for Ohio.

SEMIANNUAL REPORT OF WATERSHED MANAGEMENT RESEARCH
Intermountain Forest and Range Experiment Station
April - October 1954

Division

Consolidation of the Intermountain and Northern Rocky Mountain Stations necessitated reconsideration of the watershed management research problems in the enlarged Station territory, as well as the continuance of current research efforts, pending shifts and changes that may be indicated by an over-all analysis. Craddock made several trips into the R-1 area as a basis for a preliminary consideration of the problems in that portion of the Station territory.

The first of these trips was made with Frank to observe runoff conditions in western Montana and northern Idaho during the spring snowmelt period. Record snow accumulations posed a possible repetition of the 1948 flood on the Columbia. Cool temperatures and lack of rain minimized the threat, though several tributaries reached damaging flood stages. Evidence observed on this quick trip pointed to the need for a more critical look at logging road locations and cutting practices in spruce-fir forest lands.

Two trips were made into Montana to discuss a beaver watershed problem with the Montana Game Department. One trip involved the inspection and tentative location of several stream reaches in southwestern Montana on which the State game people may initiate detailed studies of the hydrologic and biologic affects of beaver. There is a possibility that we may wish to cooperate in this effort if the upstream areas are found to be suitable for watershed management research.

Attendance at a field meeting of the R-1 Inland Empire Advisory Council provided a further opportunity to observe and discuss watershed management problems in the Clearwater area, especially the problems that may be created by construction of very high dams. Here, problems of maintaining soil stability on very steep slopes following fire, logging, and road construction, need a more critical look.

As a step toward finding the solution of the watershed problems in R-1, Paul E. Packer will be transferred to the Missoula Research Center late this fall. His first efforts will be a critical analysis of problems on both the Columbia and Missouri headwater areas. Harold F. Haupt will remain at the Boise Research Center to continue studies on forest and range lands.

Boise Research Center

Boise Basin Experimental Forest - Main emphasis has been concentrated on the comprehensive ponderosa pine production-sediment evaluation study initiated in 1953. This spring and summer the Watershed Management Research staff completed a followup survey of erosion damage resulting from winter snowmelt runoff on the first replicate of eight logged compartments. On the experimental watershed within each compartment this included the measurement of sediment (1) originating on logging roads and skid trails, (2) in transient along the drainage bottoms, and (3) that actually trapped behind small wooden dams at the mouth of each logged watershed. The latter involved reshooting with an engineer's level the grid system of sediment measuring coordinates in each catchment basin.

Integrated with this erosion survey was a mapping job of all forest floor disturbance caused by logging. This sets the stage for correlating each type of logging (small cat or large cat) and each method of timber marking (stemwise selection or group selection) with kind and extent of logging disturbance.

Additional effort, still in progress, involves the building of more plank and post dams for catching sediment from the second replication of eight compartments to be logged this fall.

Beaver Creek Post-Logging Treatment Area - During 1952, several hundred case histories involving the effectiveness of logging road cross-ditches and skid-trail treatment for control of runoff and erosion were obtained from five timber sales on granitic soil on the Boise National Forest. These data are not yet completely analyzed. However, preliminary inspection of the information obtained indicates that cross-ditches should probably be spaced as follows for prevention of rilling and gullying on road surfaces.

Road Gradient (percent)	Cross-Ditch Spacing (feet)
5	100
5 - 10	75
10 - 15	50
15	25

Further analysis of the information from these observations is being made with the objective of providing R-4 and R-1 with tentative guides for post-logging treatment sometime this fall or early winter. This analysis may indicate some deviation from the spacings indicated above, depending upon physiographic location with respect to drainage bottoms and ridges and with respect to coarseness of soil.

During 1953 and 1954, a study to evaluate the influence of cross-ditch spacing on roads and of different spacings of slash gully plugs and water-bars vs. solid lop and scatter of slash on skid trails was initiated on the Beaver Creek sale area of the Boise National Forest.

This area is near the upper elevational limits of ponderosa pine. Three different intensities of treatment were installed on each of three different gradients of roads and skid trails. Observation of road and skid trail surfaces following spring snowmelt and after each summer storm, together with measurements of rill and gully dimensions, should provide a basis for determining effectiveness of treatments for minimizing erosion.

Plans have been made with the Boise National Forest to install a similar study on the current Grape Mountain sale area, bordering on the lower elevational limits of ponderosa pine and characterized by drier, hotter sites with coarser soil than the Beaver Creek area. Similar arrangements are being made for studies in the Salmon River South Fork and Weiser areas of the Payette Forest. These two areas are characterized, respectively, by somewhat finer granitic soil and heavy basaltic soil. The studies on these areas constitute an evaluation of the criteria developed from the 1952 observations.

Arrowrock Range Watershed Demonstration Area. - In 1953, in cooperation with the Boise National Forest, a restoration program was initiated as a demonstration in a small watershed of approximately 300 acres at the Arrowrock Substation in the foothill range. Part of the demonstration included three runoff and erosion plots, each 48 feet by 16 feet in size, to demonstrate the effectiveness of rehabilitated range as compared to depleted range for controlling summer storms runoff and erosion. During the spring of 1954, a fourth plot was installed in order that the demonstration could also be used for a study design. A study plan for the plots was developed, the essential features of which areaas follows:

1. Two plots remaining in sparse annual weed cover characteristic of depleted range.

2. Two plots reseeded with a view toward providing good perennial grass cover.

3. One plot of each kind to remain undisturbed to characterize protection from grazing.

4. One plot of each kind to receive trampling disturbance and clipping of cover to simulate continued grazing use.

Early spring thawing and frost-heaving of seedlings prevented successful establishment of a good stand of grass on the reseeded plots during 1954. These plots are to be reseeded again this fall. In addition to measuring soil losses from these plots, the station is undertaking to keep track of the trend in condition of vegetation and ground cover on the plots as a basis for evaluating losses in relation to cover requirements for protection under grazing pressure.

FS History Office
Reference Shelf

Watershed Division Training and Work Meeting on the Boise Basin Experimental Forest - In August, the entire Watershed Division met at Idaho City for the joint purpose of expediting the watershed field work on the Experimental Forest in Bannock Creek and discussing past program, present status, and future needs for Watershed Management Research within the Boise Research Center area. The group visited the foothill range area where the work on protection requirements and the need for cooperative investigation by the Range and Watershed Divisions was reviewed. One day was spent in meeting with the Forest Management Division with Curtis reviewing the ponderosa pine production study on the Experimental Forest in considerable detail. Work accomplished included referencing and gridding of three more sediment dams and continuation of postlogging disturbance survey. The need for basic hydrologic investigations on a watershed basis, both on range and ponderosa pine timberlands, was pointed up in the discussions of future program requirements.

Show-Me-Trips - The Watershed Management Research staff at Boise participated in four show-me trips this summer. One of these, in conjunction with the Boise Forest, was to show University of Idaho range students the range watershed problems and research program on the lower mountain and foothill areas. Two trips were made with as many groups of Turkish foresters for the purpose of reviewing the WMR program, both on range and timberlands. In cooperation with the Forest Management Division and Boise National Forest, the WMR staff briefed the Boise Forest Advisory Board on the research program being conducted on ponderosa pine in the Experimental Forest at Idaho City.

Wasatch Research Center

Streamflow - The Davis County Experimental Watershed appears to have been in the center of one of the lowest precipitation areas experienced in Utah in many years. Runoff from the experimental watersheds this year has been the least since the severe drought of 1933-34. Precipitation at Farmington, Utah, from October 1, 1953 to April 30, 1954 was 7.74 inches. This is .42 inch less than for the same period in 1933-1934, but antecedent precipitation was greater. All water users in northern Utah are hopeful that snowfall during the coming winter is at least normal because another low-precipitation winter would surely mean deficient water supplies next summer and fall.

It was previously reported that runoff from the Parrish Creek watershed has declined consistently in relation to the flow from the adjacent Centerville Creek since 1936. The net decrease over this period of years has been on the order of 2.0 area inches, or about 15 percent of the average annual runoff. It was first assumed that the diminishing yields were due to reinvasion of the ripped and deepened channel by riparian vegetation. Month by month analysis of streamflow records, however, show the decline in runoff from Parrish Creek since 1936 has occurred mostly during high water in the spring. This suggests a significant change has occurred in the mantle storage opportunity on the headwater lands rather than any great increase in evapo-transpiration by riparian vegetation along the lower channel reaches, as previously

assumed. A start was made this fall on a study of soil depletion moisture conditions on a number of headwater sites. Included were poised observations on flood source areas in improved and unimproved condition, as well as some nonflood source areas. Findings from this supplemental study should furnish a clue to the changed streamflow behavior of Parrish Creek.

Plant Cover Changes on Morris and Miller Watersheds - Two graduate students from the University of Utah completed a study of vegetational changes on the Morris and Miller watersheds. Records obtained in 1953 were compared with data obtained from plots established in 1936. The highlights of their findings:

A. Morris

1. Litter in the lower half of the watershed increased from an average depth of 1.8 inches in 1939 to 2.5 inches in 1953.

2. In the upper part of the watershed it increased in depth from 0.3 to 0.6 inches during this same period.

3. The density of vegetation at lower elevations increased from an average of 54.2 to 69.8 percent.

4. In the upper portion of the watershed there had been a substantial decrease in vegetative cover. (The upper portion had been grazed prior to 1936. Perhaps the increase in litter was due to the cessation of grazing even though total plant cover decreased.)

5. Species that had decreased markedly in amount of area covered were Pachistima myrsinites, Sambucus microbotrys, Populus tremuloides, and Artemisia tridentata.

6. Most of the other plant species, on the average, increased in density.

7. No one species was found to dominate the watershed, but the shrub class, below 4.5 feet in height, comprised the greater portion of vegetative cover on the watershed, especially at lower elevations.

B. Miller

1. In general, litter has increased in both depth and area on this watershed.

2. Area covered by vegetation in 1953 was 2.43 percent greater than in 1939. This gain was due to a large increase in density of shrub type plants growing below 7,600 feet elevation. The area above this altitude decreased in cover although it was the area severely abused by grazing prior to 1936.

3. In general, grasses decreased in density but this decrease was concealed by an increase in Carex sp. Carex sp. doubled in intensity.

4. Shrubs accounting for most of the increase in density below 7,600 feet elevation were Acer glabrum, Ceanothus velutinus, Physocarpus malvaceus, and Prunus melanocarpa. Ceanothus velutinus made large increases in density and height on an old burn area.

5. Major decrease in density at altitudes above 7,600 feet was due to losses in Artemisia tridentata, Sambucus microbotrys, Symphoricarpos oreophilus, Prunus melanocarpa, and seedlings of Populus tremuloides.

6. Woodland species, mainly Populus tremuloides, and high forest trees, mainly Abies lasiocarpa, increased in density. On a few plots high forest trees had died as a result of disease and insect damage. The number of seedlings was greatly reduced for all high forest species.

Cooperative Session at Wasatch Research Center - As a followup of the successful joint session at the Boise Research Center, Howard Orr and Harold Haupt spent the week of September 13-17 at Wasatch Research Center. Their assistance was greatly appreciated.

Some time was devoted to a discussion of the publications by Wilm, and by Kovner and Evans, on how long experimental watersheds should be calibrated and treated. It was decided that either method could probably be used and that the nature of the data at hand would determine which method was most applicable. One item of great interest was the implication in the Kovner and Evans publication that changes as small as 6 percent of the average annual streamflow at Coweeta might show statistical significance after seven years of treatment. Records from Miller watershed indicate that it would take 27 years of records after treatment to show that six percent of the mean flow, from 16 years of calibration, would be statistically significant.

Three stacks of Colman soil moisture units were installed during the week. Installation was made by drilling in from the face of a pit. Lead wires from the unit are brought up out of the pit and attached to bolts on a piece of plexiglass supported by a post that stands 4½ feet above the ground surface. Above ground, portions of rubber covered lead wires have been encased by metal to prevent damage by porcupines.

Units have to be installed from pits because stoniness of soil makes auger holes impossible. Stones also make accurate volume weight determinations difficult if not impossible. So far, at Wasatch Research Center, most volume weight determinations have been made from handpacked samples. Some samples were taken to check this method. Although most of these samples have not been analyzed the readings taken with a soil permeameter do not appear to be correlated with the handpacked samples.

Soil Moisture-Strength Survey - A soil moisture-strength survey was initiated during the summer by a three-man crew from the Vicksburg Infiltration Project. This survey is to serve two purposes: (1) to obtain information on soil strength characteristics, and (2) to obtain information for checking the accuracy of soil-moisture predictions developed at Vicksburg.

The survey is based on observations to be taken at 148 sites in Utah, Nevada, and Idaho. These sites represent a wide variety of soils. One plot 15 x 21 feet in size has been established on each site. These will be visited eight times before June 1955. On each visit soil samples will be taken for soil moisture determinations to a depth of 18 inches, along with penetrometer tests. Remolding index measurements will be obtained on two occasions during the year under moist soil conditions. Bulk soil samples at each site have been obtained at 0 to 6-, 6 to 12- and 12 to 18-inch depths for texture, organic matter content and plastic limit tests. Duplicate undisturbed soil cores for 3-inch depth increments have also been obtained for determining bulk density, and the moisture content at saturation and 60-centimeter tension.

Great Basin Research Center

A considerable portion of Orr's efforts during the summer were devoted to revision of his manuscript report on the findings from the Area A and B watersheds, including the preparation of charts, curves, and other illustrative material. He also spent a week each at the Boise and Wasatch Research Centers assisting on installation jobs where several hands were needed.

Precipitation in the Ephraim Creek watershed followed a most unusual pattern during the spring and fall periods. April precipitation, (normally a wet month) was only about 50 percent of normal throughout the entire elevational range of the watershed (5,580 to 9,860 feet). During September, which is normally the driest month, precipitation ranged from 200 percent of normal at the upper elevations to 400 percent of normal at Ephraim. Midsummer precipitation was about normal with no summer storms of outstanding violence. The greater than average September rainfall by substantially recharging the soil mantle could result in a good water supply next year, providing winter precipitation is also normal or better.

NORTHEASTERN FOREST EXPERIMENT STATION

Division of Watershed Management Research

Semi-annual Report October 1954

GENERAL

Since we didn't report on our work in the last semi-annual report, this will cover, in a brief way, a year's work. During that year a number of things happened which affected our program, ranging from last fall's drouth to this summer's Congressional appropriation for watershed research in New England. Between times we had a fire on the Dilldown, several personnel changes (not related to the fire), and a consolidation which merged the Delaware Research Center with the Anthracite. We've had our share of visitors and in turn visited our share. And we chalked up another water year calibrating our watersheds.

KINGSTON RESEARCH CENTER

This report marks the end of the Delaware Basin Research Center as a separate entity and the end of our six-year association with Lehigh University. Effective June 1, the office in Bethlehem was closed and the files, furniture, and equipment were moved to Kingston, Pennsylvania, the headquarters of the Anthracite Research Center.

The Kingston Research Center, the official name of the consolidated center, was formed in the interests of economy and to promote greater efficiency. Both the Delaware-Lehigh Experimental Forest (Dilldown Watershed) and the Pocono Experimental Forest are closer to Kingston than to Bethlehem. Watershed studies at both forests will be continued as usual.

Trough-type Raingages

In interception studies trough-type raingages have certain distinct advantages over the standard circular, 8 inch diameter gages. They can be made up very cheaply. In measuring throughfall in brush cover, a long narrow trough samples throughfall under a considerably larger variety of cover conditions than a circular gage can possibly sample.

Accordingly, trough-type gages were used in our interception studies, both in scrub oak and high forest. Three gages were placed at random beneath the canopy, while a single gage was located in a nearby opening to measure total rainfall.

(Over)

In actual use, the surface area of the mouth of the gage is measured, and if placed on a slope to drain adequately, corrected by the degree of slope. Theoretically, a hemispherical trough such as a standard eaves gutter will catch and hold (or deliver to a container) all the rain falling into it.

Nevertheless, the suspicion arose that our trough gages were not catching an adequate sample of rainfall. As a preliminary test, standard weather-bureau type raingages were located immediately beside the trough-type gages in the open and comparative measurements were made. At every installation where these comparative measurements were made, the circular gage caught more rainfall than the comparable trough gage.

A gage will not catch more rain than falls, but it is possible for rain to splash out of or be blown away from a gage. Therefore, when there is a varying catch in two adjacent gages, the higher amount is taken as the best estimate of the rainfall. We were forced to conclude that our trough gages in the open were not catching a typical sample of total rainfall.

Following the reasoning that some of the rain must have splashed out of the trough gages, new gages were made with 3-inch vertical sides above the hemispherical part of the trough to reduce splash. To test the effectiveness of the new gage, a more detailed study was conducted this past summer.

In the opening at one of our interception stations, a series of circular gages were placed with one of the new, high trough gages and four of the old, low trough gages. The old gages were sloped in each of the four cardinal directions in an attempt to determine some effect of wind on the deficiency of the catch in the low troughs.

Analysis of the measurements is now nearly complete and some tentative conclusions have been reached. The low trough gages again caught less than the circular gages. On a seasonal total, the differences are important. Variation between the circular gages was very slight; seasonal differences were negligible. The higher trough gage caught slightly less rain than the circular gages but the difference was not significant.

We have been able to detect no effect of wind direction or the direction in which the trough gage was sloped. Degree of slope, an unsuspected variable, appears to have had an effect on the catch: the greater the slope, the greater the catch. The trough with the greatest slope, 11 degrees, had the highest total catch; the difference in catch between it and the high trough was barely significant. The catches in the other three troughs were highly significant in their differences from the high trough. The differences were inversely related to the degree of slope.

Averaging the four low trough gages, the catch per storm was related to the best estimate of the rainfall for the respective storm. With P representing the best estimate of the rainfall, and T representing the average catch in the trough gages, then $P = 1.041T + 0.008$. The equation shows a considerable difference between the trough gage catches and actual rainfall. Thus, our previous interception determinations may be revised considerably.

Soil Freezing

This past winter we initiated a laboratory study of soil freezing with the specific objective to determine the soil, water, and temperature characteristics important in the formation of different types of frozen soil. The study was limited to three textures; soil, loam, clay; three levels of freezing, 25, 15, and 0° F, and a range of moisture content from oven-dry to saturation. Soils were frozen in a small home freezer.

By controlling these variables we were able to manufacture only concrete frost. This frost was of two types: one with visible ice lenses or strata, the other a consolidated mass of soil with varying degrees of hardness which contained no visible water in crystalline form. We have called the latter type "homogeneous concrete frost." This type has been encountered often in the field, but was always identified as concrete frost.

Within the limits set by the experiments, we found that texture has a decided influence on frost type. In sands, only homogeneous concrete frost formed. In loams concrete frost formed but only thin ice lenses were generated. In clays concrete frost formed, but the frozen water took the form of ice strata.

Moisture content also affects the freezing of soils. First of all, some moisture must be present for the soil to assume a consolidated form. Oven dry soils and those with a low moisture content remain unconsolidated. Some moisture must be present to bind the soil particles together. The amount of moisture required depends on the soil texture. Thus, sandy soils require only a small amount of water, whereas clays require a great deal more water to bind the particles. The requirement of loams lies between the two extremes.

A second effect of moisture content is on the hardness of the frozen soil mass. Although precise measurements were not taken on the force required to crack open a frozen soil, it was evident that soils with high moisture levels froze into a very hard mass, whereas those with less water did not freeze as hard.

The effect of rate of freezing was difficult to detect. Beyond the obvious result that soils frozen at 0° F. froze much faster than those frozen at 15° F. or 25° F., there was only one other discernible effect: sandy soils frozen at 25° F. did not freeze very hard, whereas those frozen at 0° F. did freeze into a hard mass, the degree of hardness depending on the moisture content.

Apparently the most promising avenue of approach toward producing granular or honeycomb frost lies in studying the effects of compaction and structure.

Fire

On October 21-22, 1953 fire burned over 325 acres in the lower part of Dilldown Watershed (total area 1800 acres). The watershed project is still in the period of calibration and fire is not an unusual condition in the natural state of the watershed. The burned area contained the oldest and largest vegetation on the watershed aside from the high forest along the creek.

Scrub Oak Conversion

Anticipating the end of the calibration period of the Dilldown Watershed, plans are being made to change the present vegetative cover to a high forest cover. Most of the watershed is now covered with brush, pure scrub oak in some places, elsewhere scrub oak with an intermixture of chestnut, pitch pine, red and white oak, red maple, gray birch, and sassafras.

These other species, with the exception of chestnut, are emerging from the scrub oak cover and will compete successfully with the intolerant scrub oak. Where these species are frequent enough, they will form a closed canopy if protected from fire. Other areas may need some supplementary interplanting to complete the high forest cover. Pure scrub oak areas will require complete conversion, of course, as the natural conversion process is extremely slow with no competing vegetation.

The gray birch, sassafras, and possibly red maple will have no commercial value but are considered to be adequate to form a closed canopy for the watershed studies. To form a complete cover of commercial species would be more expensive and much more difficult.

Reigner has spent considerable time on this planning, using information gathered in the vegetation survey of the watershed. Several alternative plans will be prepared, using the various conversion methods now considered practical.

Soil Moisture Installations

Additional soil moisture units were installed at two sites. The thought behind the installation of these units was that the data they furnished would eventually replace those yielded by deteriorated units installed a few years ago. In this way, a continuous source of soil moisture data would be available.

Groundwater Measurements

The watershed study at the Pocono Experimental Forest has never had groundwater control. Without a well into groundwater, it is difficult if not impossible to determine base flow or to determine when recharge occurs.

After the dry summer experienced in the Poconos, groundwater was at a low level. Accordingly, test holes were dug to determine where groundwater could be measured without the expense of drilling a deep well. The first hole was dug in a flat area about 75 feet from the stream. Water was reached at a rather shallow depth, but lay at the same level as the stream. As this well was obviously being recharged by the stream, a second hole was dug at a higher level, and farther from the stream. Water was also struck at this location and its level is higher than the stream surface. Further testing is necessary, but it appears that the second location will be suitable for the development of a shallow groundwater well.

Infiltration Project

The Northeastern Extension of the Vicksburg Infiltration Project began operation at the Kingston Research Center in June. The purpose of this work is to determine soil strength characteristics and check soil moisture predictions at representative soil-cover sites.

Working with available Soil Survey maps, 133 sites were selected in six northeastern states, Pennsylvania, N. Y., Conn., Mass., N. H. and Vermont. To facilitate efficient and economical sampling trips, the area was divided into two circuits, eastern and western. The eastern circuit covers eastern N. Y. and all states east. The western circuit covers Pennsylvania and western N. Y. Mileage and number of sites are similar for each circuit.

The sampling schedule calls for five visits to each site before the soil freezes. To date, three visits have been made to the eastern circuit and four to the western circuit sites. On each visit soil moisture and soil strength measurements were taken. Bulk samples were taken on the initial round and have

been sent to Vicksburg for mechanical analysis. Remolding data and ring cores for bulk density and tension data will be taken when the soil is moist.

Ralph Moyle, transferred here from Crossett, Arkansas, is in charge of the survey. He is assisted by Beryl Jones, transferred from Colorado, and Arthur R. Eschner transferred from Central States.

MOUNTAIN STATE RESEARCH CENTER

The Elkins-Parsons combine is generating considerable interest in studies of logging road design and construction. The aim has been to develop logging methods by which the logs can be brought out of the watershed without bringing the soil too. In the next-before-last semi-annual report was described first year results from vegetating skid roads with chaff. The results, by treatment, for the second year parallel the first year's results.

Mechanical disturbance caused no significant difference in cover density either on the limed and fertilized plots or the plots which were not limed and fertilized.

The limed and fertilized plots showed a significantly greater percent of vegetative ground cover (at the 1% level) than the plots which were seeded but not limed and fertilized.

The control or untreated plots showed significantly less cover density than either of the other two groups.

Table 1.--Treatment Effects on Vegetation Density

Treatment	Percent Ground Covered by Vegetation		
	First Year: 1953	Second Year: 1954	Increase the second year
Seeded only (A&B)	26.0	34.0	8
Seeded, limed & fertilized (C&D)	40.0	59.0	19
No seed or treatment (E)	0.5	16.0	15.5

Species composition changed appreciably the second year. Timothy became the predominant grass species; the proportion of the cover made up of weeds increased sharply; local herbaceous forest species entered into the composition; and maple reproduction was frequent.

In general, plots which were seeded, limed, and fertilized have produced a vegetation cover which in its second year is an effective erosion retardant. It is doubtful if on the other plots the sparse vegetation now present is offering much protection against soil washing.

This year our revegetation study has been broadened to include a section of logging truck road, additional soil types, and the seeding of Sericea lespedeza as well as chaff.

Bear Run Truck Road Study

Logging in this hollow began in November 1953 and will end in the spring of 1955. We have found that during rainy weather the amount of sediment in the water has increased 20 to 30 times what it was before disturbance of the hollow. Where the water was once pure and fit for any use practically all the time, it now runs free of silt only at very low flows during dry spells. Eventually we hope to learn how long it takes nature to "clean up" a stream after logging.

Watersheds

Calibration of our 5 gaged watersheds is continuing. We have three years of record and in a couple more years we will begin cutting to show the effect of different types of forest management and road standards on these water values: sedimentation, total water quantity, peak flows, low flows.

WHITE PINE HARDWOOD RESEARCH CENTER

Watershed management research in New England will start this winter. Currently, we have two jobs--find an experimental area and develop a research program. Vic Jensen, research center leader, Lull, and Trimble have been conducting a search and hope to have an area picked out shortly. The program--we're thinking about it and we've asked some leading thinkers to help us out.

The work was made possible by a $50,000 Congressional appropriation this past August. It culminates years of planning and hoping--the Copeland Report called for this research in 1933.

Present plans call for Dick Trimble to head up the Project assisted by Dick Sartz from the Washington Office PI Project, and others to be appointed later.

PERSONNEL

In mid-January this year Herb Storey moved to Washington, D. C. to take on the job of Chief, Division of Watershed Management Research.

In June Ned Bethlahmy took educational leave to attend Cornell in quest of a Ph.D., majoring in soil physics.

In August Howard Lull turned up to take Mr. Storey's old job.

PUBLICATIONS

1. Do We Need Watershed Research in West Virginia by Sidney Weitzman, West Virginia Conservation, February 1954.

2. Foresters Are Important on the Watershed by G. R. Trimble, Jr., West Virginia Conservation, March 1954.

3. Effects of a Hardwood Forest Canopy on Rainfall Intensities by G. R. Trimble, Jr., and Sidney Weitzman. Trans. A60, April 1954.

4. Report No. 2. Forest and Water Research Project, Delaware-Lehigh Experimental Forest by H. C. Storey, W. E. McQuilkin, and Eugene McNamara, Pa. Dept. of Forests and Waters.

5. Estimating Summer Evapo-transpiration Losses in a Pennsylvania Scrub Oak Forest by Ned Bethlahmy, Soil Sci. Soc., Amer. Proc. 17:295-297.

6. Technical Articles by Ned Bethlahmy. Jour. Forestry 51: 911.

7. Home Made Gadgets Aid Forest-Influences Research by Burley D. Fridley, Jour. Forestry 51: 907-908.

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Forest Influences
Semi-annual Progress Report, April 1 - September 30, 1954

General

During the past 6 months major emphasis has continued to be promotion of watershed management research. Strong interest has been evident in the Mid-Columbia section of Washington and in the Blue Mountain and Siskiyou-Cascade sections of Oregon.

Considerable effort has also been devoted to preliminary plans for cooperative watershed research. Possibilities seem good for developing investigations by this means in the Pacific Northwest.

We were glad to have Herb Storey for a short visit during August. Cowlin, Meagher, and Dunford were his guides during the first two days when visits were made to Corvallis city watershed with Rex Wakefield, supervisor of the Siuslaw National Forest, and later to the H. J. Andrews Experimental Forest. Dean Paul Dunn and three members of his staff at Oregon State College, School of Forestry, joined the group for the tour of the Andrews Experimental Forest. They saw one of the three experimental watersheds now being calibrated and heard a brief review of plans for future watershed research. Silen and Gratkowski also discussed their program of forest management research including problems of road construction, regeneration, location of cutting areas, windfall, slash burning, erosion, and stream channel disturbance. Following this, Storey and Dunford continued on a quick swing through the rest of the region looking at areas where research is planned.

Progress on a regional problem analysis for watershed management research continues although slowly because of diversions. Hayes has completed his analysis of problems in the Siskiyou-Cascade research province. Although he placed strong emphasis on forest management research needs, his analysis included a very good summary of watershed research needs.

A flurry of writing activity has been occasioned by the forthcoming Yearbook on water. Hayes has been asked to coauthor an article on "What water means to the forest." Dunford is also working on one dealing with erosion control on forest lands.

Green River, Washington

Green River watershed, 231 square miles in area, is the source of most of the domestic supply for the City of Tacoma. The Water Department has been plagued with silt pollution resulting from activities in the watershed over which they have no control. Most of the area is forested; ownership is mixed; and logging has been carried on for more than 30 years.

Since 1946, the City of Tacoma and the U. S. Geological Survey have been cooperating in the measurement of flow on the main stream and five tributary drainages.

Primary objectives have been to determine the effect of logging on water yield and silt pollution. However, it has been difficult to maintain control over logging necessary for the conduct of long-time runoff measurements. The relatively large size of the drainages, the mixed ownerships, and the lack of statistical control have largely nullified efforts to obtain significant results in water yield.

The only measurements of silt have been obtained at the intake works. No attempt has been made to relate turbidity and particle size to source areas or causes.

During the past summer the experiment station joined forces with the Snoqualmie National Forest, the district office of the Geological Survey, and Tacoma Water Department to work out an agreement for further investigations in the watershed. Two reconnaissance trips were made in an effort to locate a set of paired watersheds small enough to be logged in one year. A second objective was to find a suitable location to study relative amounts of silt disturbance resulting from tractor and high-lead logging.

Two drainages which appear suitable for water yield studies have been located in an area of old-growth Douglas-fir. Ownership in the watershed is about equally divided between the Forest Service and a large timber company. The latter has expressed general interest in the investigative project but is withholding final decision until a working plan is prepared. The company's contribution in the project will be revision of the cutting schedule for their land included in the drainages and extension of their present access road into the area.

Bull Run River, Oregon

Since 1895, the City of Portland has obtained its entire domestic supply from Bull Run watershed. The 102 square miles above the intake is owned almost entirely by the Forest Service. The drainage is located in an area of 218 square miles known as the Bull Run Reserve. By Presidential proclamation, control over trespass and grazing in the Reserve has been established since 1892. Although no specific restrictions on bona fide timber sales have been included in the proclamation, the sentiment of the Portland Water Bureau and the public in general has been very much in opposition to any timber cutting. The Forest Service has no real information to refute claims that logging will permanently damage the water supply. Yet they are faced with growing demands from lumber interests for release of the timber which itself represents a value of over 100 million dollars.

The need for watershed research in the Bull Run drainage was explained to Water Bureau officials at a meeting held in July. It was pointed out that the Forest Service is in a poor position to continue a noncutting policy indefinitely without having real information regarding effects of logging on watershed values. Finally, it was agreed that more information is desirable. Additional discussions will be held after a plan of investigations is formulated by the station. We hope that the Water Bureau will agree to participate in some investigations in and near the Bull Run drainage when the plan is presented.

Range-Watershed Studies

At the Starkey Experimental Forest and Range, work has been progressing since 1948 on a series of experimental pastures. The major objective has been to study three rates of cattle grazing and two methods of management. Each pasture contains a small drainage suitable for combined range and watershed studies. Differential grazing treatments will be applied next year, thus severely limiting the value of any watershed research begun after that time.

A possibility still exists for measuring soil loss resulting from differences in grazing intensities. The present proposal is to establish a small sediment catchment basin in each of six pasture-watersheds. Accumulated silt will be measured volumetrically by taking successive yearly profiles of the basins. At the present stage, specific locations for the basins are being selected and possible means of financing their construction explored.

Salvage Logging

Salvage of dead and dying timber is creating serious watershed problems in the Pacific Northwest. Recent fires and beetle attacks have killed valuable timber amounting to billions of board feet. In the haste to remove this valuable material, even ordinary precautions against erosion control are waived.

One such salvage area known as the Hehe Burn was inspected by region and station people in May. The object was to determine the cause of a severe outflow of mud, rocks, and logging debris which occurred during the previous fall. The reason was obvious. Many of the factors encouraging erosion were there: Reduced protection from vegetation, rugged topography, and unstable soils. Added to this is the fact that roads were built hurriedly and logging cleared almost the entire burn in one season. Five timber sales were operating at one time; and adherence to erosion-control specifications was lax because supervision had to be spread thinly.

Loss of valuable soil and productive capacity on the eroded watershed should be weighed against the gains from timber volumes saved from decay. This would require standards of evaluation which we don't yet have.

Meetings

Watershed management research was discussed at several meetings during the past 6 months:

Yakima Valley Advisory Council. This group is composed of people interested in the management of national forest lands in the Yakima Valley. In May, the station was invited to discuss research needs, including those of watershed management. They proved to be a very responsive and keenly interested group.

American Waterworks Association. At their annual meeting in Seattle, problems of municipal watershed management were discussed in an interesting panel session. Dunford and Bullard attended a short meeting called by Steve Bergen to round up suggestions for new projects that might be undertaken by the Conservation Foundation.

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
WATERSHED MANAGEMENT
Semiannual Report -- April 1, 1954 - October 1, 1954

Fraser Research Center

The start of treatment of the Fool Creek watershed, the initiation of a new watershed study, and progress toward trial of the Wyssen Skyline-Crane for timber removal have been the principal developments during the current field season.

Logging of the Fool Creek area in a pattern of alternate clear-cut strips of four different widths was started on June 21. All live timber 4 inches d.b.h. and larger is cut and all material merchantable as saw logs, poles, posts, or pulpwood is removed. The pulpwood is piled in anticipation of a market; all other merchantable material is taken by the operator.

The completion of logging is scheduled for October 31, 1955. Subsequent water and sediment yields will be measured to determine the timber removal effects on this 710-acre watershed.

A new gaging station is under construction on Deadhorse Creek, draining a watershed of approximately 600 acres of which around 400 are timbered, the rest subalpine. This is the first stream gaging station of a new pair on similar watersheds; the second of the pair, on a stream to be christened Lexen Creek, will be built during the summer of 1955.

A primary purpose in setting up this pair of watersheds is to provide a watershed where large scale trial of the Wyssen Skyline-Crane can be made. It is planned to log Deadhorse Creek, following the necessary calibration period, using Lexen Creek as the control. Water and sediment yields will be measured.

An innovation for the Fraser Experimental Forest is the use of a sharp crested weir for gaging Deadhorse Creek instead of some type of flume as is being used on the other streams under study. An objection to the San Dimas flume is its limited range; an objection to the trapezoidal flume, the type more recently built, is the time-consuming field rating required. A foreseen disadvantage of the sharp-crested weir is the pool cleaning necessitated. The installation of a weir will enable comparisons and judgment as to the most efficient device. Compensating for the cleaning of the weir pool is the fact that the sediment yield will be measured in the process.

Trial of the Wyssen Skyline-Crane in the central Rocky Mountains has been desired for several years and for several reasons. From the watershed management point of view, the reasons are as follows: (1) In comparison with ground skidding methods requiring extensive networks of haul roads, it should result in much less erosion. (2) It should enable cheaper logging in difficult terrain and thus give greater latitude in the management practices that can be applied economically. Many forest management reasons supplement these arguments in favor of a Wyssen system trial.

Confirmation has been obtained from a Wyssen equipment expert that the topography and timber of the central Rocky Mountain area are ideally suited to use of the Skyline-Crane. Under his guidance, an area on the Fraser Experimental Forest has been chosen for the initial trial and a line located for the first cable setting. It is hoped that this first trial can be made in the summer of 1955.

Upper Colorado Research Center

Badger Wash Cooperative Study

The Badger Wash study has now been under way for 1 year. Its objective is to determine the effect of livestock exclusion on erosion and runoff in the salt desert shrub type. The study was described in the semiannual report of a year ago, and results of the first field season's work were summarized in last spring's report.

Representatives of the various agencies cooperating in the project held their first annual meeting on June 30, 1954. The progress of each phase of the study was reviewed and plans made for conducting the study during the coming year. Only one major modification of the original plan was made. This was the expansion of the vegetation study to include composition measurements in the spring as well as fall (at 5-year intervals) and utilization estimates annually in the spring.

The initial infiltration and erosion measurements started last fall will be completed in October 1954.

Oak Brush Study

This year's research in the oak brush type of western Colorado was chiefly aimed at finding out how much the oak has spread in recent years. About 50 mechanically selected oaks were cut and their ages determined on 45 representative sites. From these data a study of age class distribution will be made in an effort to determine when and where the brush has spread in the past and how rapidly it is spreading now.

Upper Rio Grande Research Center

Infiltration-erosion measurements in woodland-sagebrush

Evaluation of range reseeding on infiltration and erosion was continued in the woodland-sagebrush zone in northern New Mexico. Heretofore, measurements employing the Rocky Mountain infiltrometer were made on native ranges and where available on adjacent established reseeded stands under grazing and non-use.

During the 1954 summer field season infiltration-erosion measurements were also taken to determine the immediate effect of sagebrush removal, ground preparation and seeding with standard equipment such as a D-7 caterpillar tractor and the brushland plow. Field tests were made at two locations representing soils derived from basalt, sandstone, and shale. Infiltration, erosion, and soil physical measurements were taken on a 1-acre area in native sagebrush land just prior to and

immediately following ground preparation with a brushland plow. Additional measurements were taken after the summer rainfall period and crested wheatgrass became established. Plots were paired so that each field test was made adjacent to but beyond the zone of disturbance of the earlier test area.

Preliminary results substantiate earlier findings and conclusions; that is, preparing sagebrush land with the brushland plow results in an immediate increase in infiltration rates but these rates decrease once the bare soil is subjected to summer rainstorms:

Soil moisture at start of test	Average infiltration rate (including retention storage) 50-minute test		
	Before plowing	Immediately after plowing	After summer rains & initial stand establishment
	in./hr.	in./hr.	in./hr.
	Taos Junction - Basalt		
Dry	1.7	2.5	1.6
Wet (field capacity)	.7	1.1	.9
	Mesa Viejos - Sandstone & Shale		
Dry	1.4	2.3	(1.7)[1/]
Wet (field capacity)	.9	1.0	(1.0)[1/]
	Average infiltration rate - last 20 minutes		
	Taos Junction - Basalt		
Dry	0.9	1.7	1.1
Wet (field capacity)	.6	.8	.8
	Mesa Viejos - Sandstone & Shale		
Dry	1.1	1.5	(1.3)[1/]
Wet (field capacity)	.75	.75	(.8)[1/]

1/Remeasurement on the same site not yet undertaken. Values in parenthesis represent conditions on an adjacent area plowed and planted and established in 1952 but not grazed up to the time of field tests.

The wet runs conducted at field capacity moisture content were subjected to a 50-minute 3.5 inch per hour artificial rainfall. The surface soil compaction by raindrops and the increased soil moisture content of the soil account for the lower infiltration rates during the wet runs.

Cooperative (U.S.Geological Survey-Bureau of Land Management) Rio Puerco range-watershed study

Rainfall during the 1954 summer growing season was considerably higher than has been experienced since 1952. During July and August

there were three storms of 0-0.25 inch; seven of 0.25-0.50 inch; and one each of 0.50 to 0.75 and 0.75 to 1.00 inch.

Waterflow and sediment are measured by inflow into small reservoirs formed by earth dams. Remeasurement of reservoir profiles for sedimentation were made in June prior to the start of the summer rains. The first measurements were made in the summer of 1952.

Albuquerque Extension, Vicksburg Infiltration Project

The Albuquerque Extension of the Vicksburg Infiltration Project terminated the field work at the end of April. The final report on the "Development of Methods for Predicting Soil Moisture Content" was completed in June by R. E. Taylor and D. E. Larson.

This research center is continuing measurements on the Pine Flat site since results have direct application to the Rio Grande problems.

Some information on herbicide treatment may be of interest. One tier of units at Pine Flat was bared of vegetation by herbicide treatment in May and June 1953 and vegetation has failed to reinvade the treated area (220 sq. ft.) since that time. The treatment included:

5/8/53 -- 4 lbs. polybor chlorate
6/23/53 - 5 lbs. polybor chlorate
6/29/53 - 4.5 lbs. TCA

Herbicide was mixed at the rate of 1 lb. to a gallon of water.

Soil moisture electrical units apparently were not affected by application of TCA as occurred at Vicksburg, Crossett, and Rhinelander.

Sierra Ancha Research Center

Reseeded grass effective in controlling erosion on "Summit" watershed after 1 year

The seven "Summit" watersheds, in a granitic semidesert area, were fenced in 1926 and have been continuously protected from grazing since then with the exception of some winter grazing on two watersheds from 1926 to 1934.

These watersheds were in a deteriorated condition when the study began, with shrubs forming a large part of the vegetation cover and with only scattered perennial grasses. Natural recovery of the grasses has been extremely slow and sediment yields have continued at an excessive rate throughout the study period.

To eliminate competition and hasten the recovery of perennial grasses and the control of erosion, all shrubby plants were grubbed out of four of the watersheds (two north facing and two south facing) in June 1953 and spread uniformly over the ground as a mulch. The watersheds were then seeded to a mixture of Lehmann and Boer lovegrasses. Favorable rainfall during the growing seasons of 1953 and 1954 resulted in an excellent stand of grass for this type of site.

Sediment measurements for the summer of 1954 indicate that the grass and mulch are more effective in controlling erosion and sediment movement than the untreated natural shrub and grass cover.

The following table shows the sediment yield for the summer of 1954 (to September 7) for the seven watersheds, compared with the 1931-41 average summer sediment yield.

Sediment yields and grass density, Summit watersheds

Water-shed No.	Size	Treatment	Aspect	Sediment yield Tons/sq.mi./season: Average 1931-41 Summers	* 1954 Summer	Grass basal density (from line transects)
	Acres					Percent
1	0.37	Reseeded	South	3,144	14	0.62
2	1.23	Not reseeded	South	6,281	1,220	.07
3**	.59	Not reseeded	South	1,712	27	.17
4	.49	Reseeded	South	1,792	52	.51
5	.43	Reseeded	North	3,060	60	.60
6	1.05	Not reseeded	North	4,538	6,100	.12
7	.49	Reseeded	North	4,212	52	.26

* Does not include data for September 7-30, 1954.
** Mechanically stabilized early in the study.

Timber harvest progressing on South Fork of Workman Creek despite above-average rainfall

The timber harvest of the South Fork watershed is approximately 75 percent complete (early September) and should be completed this fall. The loggers are currently cleaning up the last pocket of white fir and Douglas-fir, which will leave to be logged only a ponderosa pine area in the upper part of the watershed.

No one seems to like the white fir. The cutters complain of the numerous limbs, the skidders hate the thick reproduction, the haulers don't like the weight, and the sawmill owner complains at the low price it brings. They will be happy to get back into the ponderosa pine and so will we.

Considerably above-average rainfall during the summer delayed the operation occasionally. Average precipitation for Workman Creek for the summer season (June through September) for the period 1938-1952, compared with that received in 1954 is as follows (all figures in inches):

	Average 1938-1952	1954
June	0.51	0.52
July	2.32	4.98
August	3.14	8.29
September	3.90	1.76*

* Includes only September 1-8 inclusive.

Of the 29 storms that occurred, 9 were less than 0.25 inch, 9 were between 0.26 and 0.47 inch, 7 were between 0.52 and 0.94, and 4 were between 1.35 and 1.76 inches.

Herbicidal poisoning of chaparral shrubs used in watershed study

Moderate and heavy grazing treatments in chaparral-grassland watersheds at the Sierra Ancha Experimental Forest have failed to change water yields appreciably. As a second treatment phase, the vegetation cover on two of the four Natural Drainage watersheds will be converted from predominantly shrub to predominantly grass types so that water and sediment yields can be compared from the two conditions.

Poisoning treatment designed to kill chaparral shrubs was completed on one 14-acre watershed during the period. The treatment consisted of spraying a 5 percent solution of brushkiller (2,4-D and 2,4,5-T in equal proportions) on the basal portions of the shrub stems. Spraying began in May and was completed in early August. Effects of the early spraying are readily apparent. The second watershed will be similarly treated in 1955.

For this treatment 4 man-days labor were required to apply 2.5 gallons of brushkiller in 19.5 gallons of diesel oil per acre. From an economic standpoint the treatment thus is impractical for application to large areas. But because it is effective in killing sprouting shrubs, it is a useful research method on relatively small areas.

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
April - June 1954

DIVISION OF WATERSHED MANAGEMENT RESEARCH

SUMMARY

	Page
General	H-1
Hursh Retires	H-1
Meginnis Appointed New Division Chief	H-1
Coweeta Hydrologic Laboratory	
Farm Land Acreages in the Southern Appalachian Mountains	H-1
Quantities and Sources of Erosion on a Mountain Farm	H-3
Channelized Flor on Land Use Watershed Extremely Sensitive to Rainfall Intensity	H-4
Turbidity and Practicing Foresters	H-6
P-RO vs Elevation	H-7
Depletion Curves	H-8
Hydrologic Notes	H-9
Visitors	H-9
Cooperation	H-9
Universities	H-10
Publications	H-11
Comments and Replies	H-11
Piedmont Research Center 1/	
Climate	H-13
Calhoun Forest Reconnaissance	H-13
Condition Class	H-14
General	H-14

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
April - June, 1954

DIVISION OF WATERSHED MANAGEMENT RESEARCH

GENERAL

Hursh Retires

Dr. Charles R. Hursh, for 25 years in charge of Watershed Management Research at the Southeastern Station, retired from active duty with the Forest Service on June 30. It is hard to imagine the Asheville office and Coweeta without him, since he has initiated and directed the watershed research program for so many years. His associates in the Watershed Management Division will miss his guidance and support in carrying out the research program that is now underway. It is hoped that he will continue to serve in a collaborating capacity to the Division, since his fund of highly specialized knowledge and experience is indispensable.

The latest reports are that, for a few months, Dr. Hursh plans to keep busy doing the many things he has wanted to complete for many years. Later plans are for consulting work in land use hydrology.

Meginnis Appointed New Division Chief

H. G. Meginnis, Chief of the Flood Prevention Survey work in Region 8, has been appointed as Division Chief of Watershed Management Research at the Southeastern Station. Mr. Meginnis is one of the few individuals who participated in both the 1940 and 1952 Coweeta Program Conferences. He is an authority on land use problems and rehabilitation in the Southeastern States from earlier work in Forest Influences and has many years of experience with the Flood Control and Prevention Surveys in this section.

COWEETA HYDROLOGIC LABORATORY

Farm Land Acreages in the Southern Appalachian Mountains

The Southern Appalachian Mountains were at one time all in forest. What changes have taken place in this forest land is a question frequently raised by visitors to the Laboratory. A tabulation on farm units in the 1950 Census of Agriculture data indicates some startling information regarding the acreages of watershed problems in the Southern Appalachian Mountain Region.

Table I.--Farm Land Use in the Southern Appalachian Mtns.

	Area Sq. Miles	Percent of Total Farm Area
Farm Forests Ungrazed	4,446	29.3
Farm Forests Grazed	1,548	10.2
Other Pasture 1/	2,593	17.1
Cropland, Incl. Rotation Pasture	6,576	43.4
Total Farm Area	15,163	100.0

1/- Not cropland or woodland; rough and brush land that is grazed.

Approximately 27 percent of the farm area in the Southern Appalachians presents critical watershed areas where, in the interest of water resources, improvement of soil and vegetation is needed. This 27% of the farm area that is subjected to uncontrolled grazing produces most of the flood water in the small headwater tributaries during intense rainstorms.

Browsing and trampling by cattle without any restrictions as to season of grazing, rotation, rest period or potential carrying capacity produces scarce forage. Trampling by cattle in search of the scarce forage alters the surface soil structure resulting in lower infiltration and decreased detention storage in the soil. The final effect is an increase in surface storm water, soil erosion, higher flood peaks, and sediment carried by the streams with more pronounced effects on steep than level land.

Most of this land is poor and too steep for cultivation or management as an improved pasture. At present, practically no research effort is pointed towards the proper rehabilitation and management of these headwater protection areas. Also, there is considerable difference of opinion as to how this 2,500,000 acre problem area can best be restored for water control. For example, (1) Where does fencing off the steep slopes, excluding grazing, and restocking to trees produce a more profitable land use? (2) What are the practical limits as to how steep mountain land can be continuously maintained as a permanent improved pasture? (3) Where are the limits on steep land that farmers can realize a greater net return by growing trees as a crop than alternate land uses? (4) Are the techniques, tools, and species of trees currently recommended to farmers adequate for converting grazed rough and brush land to a profitable forest?

There is need for an integrated research program by the Divisions of Timber, Range and Watershed Management on the 4,000 square miles of farm forestry land in the Southern Appalachian Mountain Region before the flood source and erosion problem on this area can be corrected.

Quantities and Sources of Erosion on a Mountain Farm

Prior to clearing Watershed No. 3, the amount of sand and gravel caught in the ponding basin was estimated as 1.8 tons per year. After conversion to a mountain farm soil losses increased and one interesting point in Figure 1 is the irregularity in which sediment was carried off during different periods. This is partly explained by the fact that eroded material may be moved only a short distance by average storms, but is poised by this process so that a large amount of sediment will be carried out of the watershed by an exceptionally large storm. For example, during the 9th year after the mountain farm had been established, a single storm of 3 inches of rainfall moved 76 tons of rock and sediment.

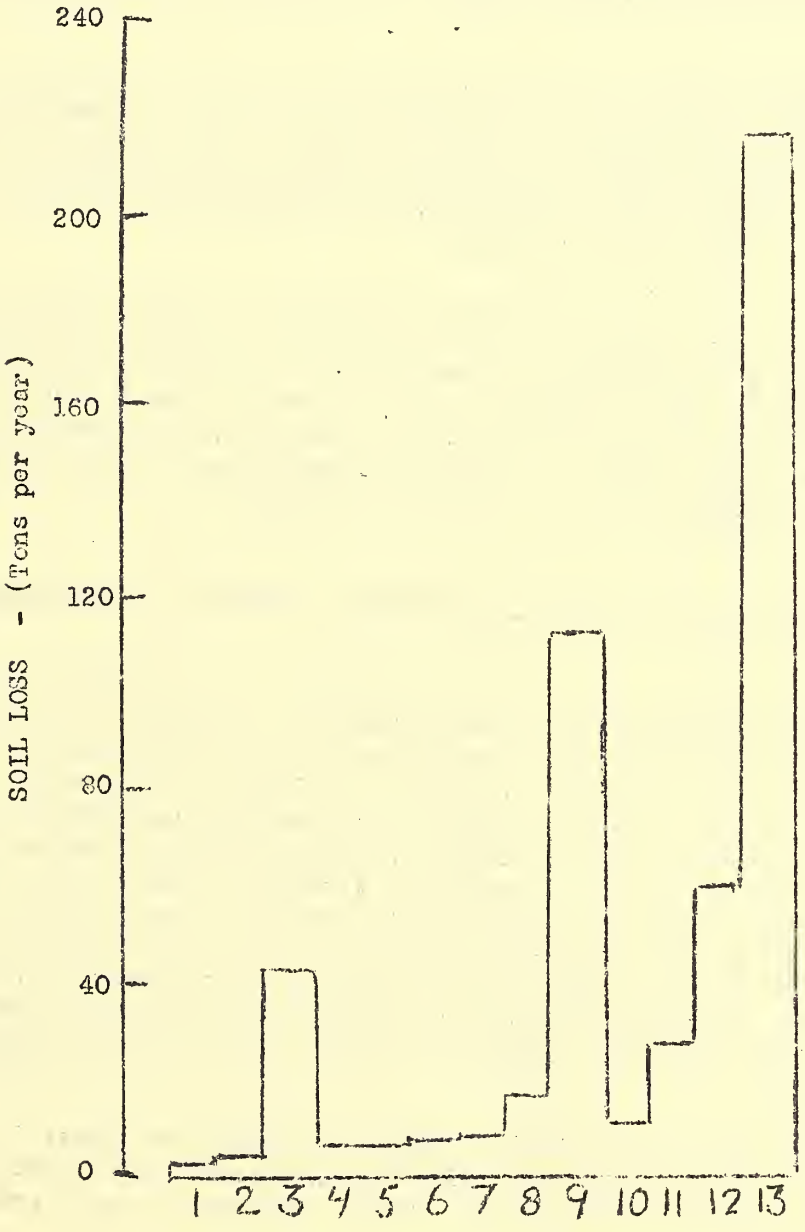


Fig 1-Average yearly soil loss from a mountain farm watershed during the first thirteen years after clearing from a forest

For the first three months of 1954, seven storms lodged 200 tons of debris in the catchment basin. Approximately 480 tons of sediment have been removed to date from the catchment basins after conversion to a mountain farm.

The first mineral soil to be exposed was the plowed cornfield, but the soil did not wash into the streams at once. However, from the first there was a gradual movement of soil within the cornfield itself. The surface soil was first transplanted from steepest slopes to the more level portions of the field near the bottom of the slope before any silt was actually carried out of the field. By the 3rd year, some of the loose soil accumulated at the lower edge of the cornfield was carried into the streams during intense storm periods. As the amount of surface storm water increased on the scalded portion of the field, this water collected in natural drainage lines and cut through accumulations of loose silt on the lower slopes carrying considerable quantities into the stream.

The pastured portion of the watershed indicated no conspicuous movement of loose surface soil from one portion of the pasture to another. Compaction appeared to take place quite uniformly over the whole trampled area. Rainfall that accumulated on the area moved over the surface as a thin layer of water producing sheet erosion and muddying up the live stream at once.

The greatest obvious change in the surface features of the watershed took place in the stream channel which was widened, lengthened and entrenched. After 10 years the channel banks which had originally been rounded and covered with vegetation were cut away leaving vertical side walls to the stream channel. These sides then became undercut by the increased storm water and this process accounted for a considerable portion of the sediment removed from the catchment basin in the last few years.

Channelized Flow on Land Use W. S. Extremely Sensitive to Rainfall Intensity

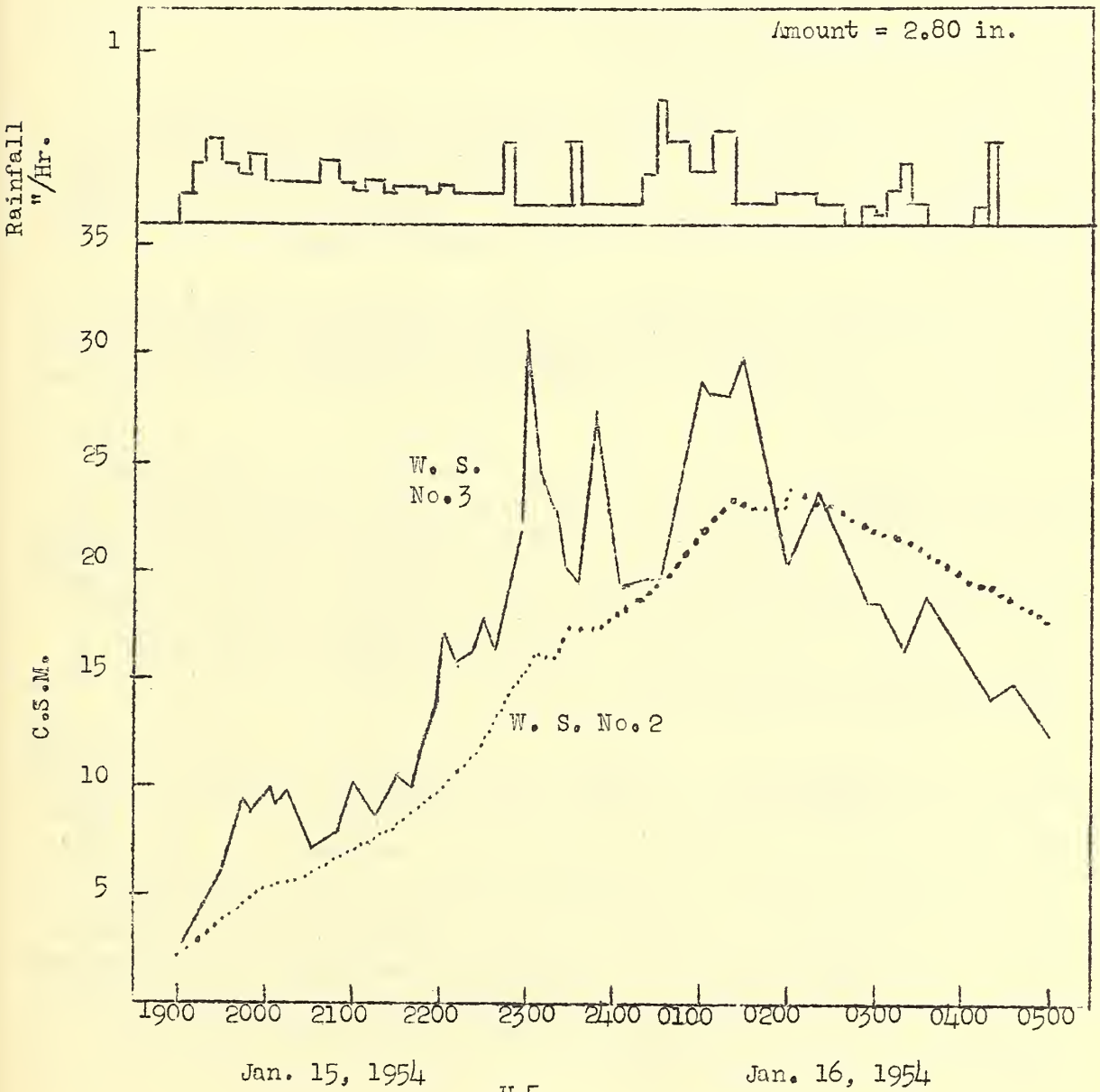
Earlier quarterly reports have considered the magnitude and frequency of maximum storm peaks on Watershed No. 3 (Mountain Farm) associated with poor land use. This discussion deals with stormflow characteristics that have been observed on a land use watershed resulting from changes in channel characteristics and channelized flow. During the winter and spring of 1954, the watershed was becoming extremely sensitive to changes in rainfall intensity. Each burst of rain had its effect upon the storm hydrograph producing a many-peaked storm as compared with adjacent forested watersheds which would produce a single peak. In fact, rainfall intensities in short bursts were better reflected on the hydrograph than on a Ferguson intensity gage with a 9" capacity and daily rotation (1.5" on chart = 1.0" P, 1.0" on chart = 125 min. time).

The storm of January 15-16, 1954, illustrates the sensitivity of Watershed No. 3 and an adjacent undisturbed, forested watershed, Watershed No. 2 to a low intensity winter storm. Watershed No. 3 produced

14 sharp and distinct peaks during the same period that Watershed No. 2 produced four rounded and minor peaks (Figure 2).

Storm observations throughout the winter period coupled with earlier observations on the watershed point to increased channelized flow as one of the principle causes for this phenomenon. Increased channelized flow not only results from an actual widening and lengthening of the flowing stream channel, but also from channelized flow accompanying rill and gully erosion. Increased overland flow through rill and gully erosion has actually changed the pathway of ephemeral streams and has caused a change in the natural synchronization of stormflow on the watershed. This factor may also explain the multiplicity of sub-peaks.

Fig. 2 - Sensitivity to Rainfall Intensities of W. S. No.3 as Compared with W. S. No. 2



Some of the increased sensitivity might be attributed to the lack of ameliorating influence on rainfall intensities by forest vegetation. A study was made of the hydrograph of a clear-cut watershed (W. S. No.17) for the same storm which indicated only an insignificant portion of the change in sensitivity would be due to removal of the forest cover.

The change in the nature of the hydrograph during early 1954 raises a question as to the possibility of the unit hydrograph approach on small watersheds with adverse land use. The changes in channelized flow, producing a series of peaks instead of a single peak, would make it extremely difficult to obtain records that meet the exacting requirements for unit hydrograph analyses.

Turbidity and Practicing Foresters

The use of stream turbidity as an index of good watershed management is not new. Practicing foresters, however, have shown a reluctance to use turbidity as a tool in watershed management, probably because they are unfamiliar with the mensuration of turbidity. We are passing on some of our experience with the hope it will lead to a wider appreciation of stream turbidity by more forest managers.

What is turbidity? -- Turbidity is an optical approximation of suspended matter in water resulting from interference to light rays through a water sample. It is always in comparison to a standard sample of silica in distilled water. Recorded turbidity is expressed in parts per million (p.p.m.).

How is it measured? -- The method of measurement used by water works personnel is based on the depth of sample required for the image of a standard candle to disappear when observed through the suspension. The standard instrument for making such measurements is called the Jackson turbidimeter. A photometer utilizing an ultra-violet light source provides a rapid means of obtaining turbidity measurements. For highly turbid samples, a volumetric and weight determination by filtering the solid material, oven drying and weighing, will give more accurate and consistent measurements.

Where is it best sampled? -- Sampling for turbidity in a large stream can be a complicated procedure, but the usual branch or creek with a forest property or timber sale area (20 feet or less across) is so small that depth and position of sampling become minor considerations. One sample at a given time and place is usually adequate. It should be taken at the base of the watershed and preferably in turbulent, free-falling water such as commonly flows over a small cascade or rock. A pint-size Mason jar with separate lid and screw-type cover makes an ideal sampling vessel. Pertinent information can be copied on a notebook-size sheet of paper, placed over the lid and screwed down, thus reducing the possibilities of a lost record.

When should it be sampled? -- Time of sampling depends upon whether values for storm periods or non-storm periods are desired. If storm period values are necessary, the best time to sample for maximum values is during a high-intensity storm while the stream is still rising and as near the crest as possible. Samples obtained at other times than during maximum storm flow will under-estimate the maximum turbidity from the stream. Non-storm period samples should not be taken within 48 hours of the end of a major storm or the sample will be an over-estimate of the normal non-storm period turbidity.

How much is serious? -- The amount of turbidity that constitutes a threat to good watershed management is in part dependent upon the ultimate use to which the water is put. For example, water for domestic use in North Carolina must have less than 10 p.p.m. turbidity by state law. Various industries have their own standards, ranging from extremely high standards necessary for the manufacturing of cigarette paper to relatively low standards in industries where water is primarily a cooling agent.

A few examples might be useful in visualizing degrees of turbidity. Ten p.p.m. viewed in a pint Mason jar leaves water clear enough so that printing on pocket-size notebooks can be read through the sample. For a 100 p.p.m. sample it is just possible to discern the blurred outline of a black pencil, and with 1000 p.p.m. it is so thick that a Jeep headlight beam will not pass through it.

How can its sources be located? -- The stream is the best indicator of erosion on a watershed. The best time to trace for sources of excess turbidity is during or immediately following major storms. Simply following the stream course back to the confluence of the tributaries and following up the most turbid tributaries will usually lead to the cause. During non-storm periods, an examination of channel bottom conditions provides clues to the amount of storm turbidity and indicates sediment source areas. Pools filled with sediment, and rocks with an upstream cone of silt behind them usually indicate high turbidity. Road construction, logging, clearing and cultivating, excessive grazing and trampling are common causes that can be traced back in this manner.

Elimination of the causal agents by erosion control measures should reduce stream turbidity during the next major storm. If it does not, the time has come to call in an expert versed on soil erosion characteristics and forest land-use classifications. Unconquered erosion as expressed in turbid streams is also an indicator of damage to the future timber crop.

P-RO vs Elevation

The difference between yearly precipitation and run-off constitutes consumptive use or water losses if no leakage exists in a unit watershed. Within each undisturbed watershed at Coweeta, P-RO is surprisingly constant, the small differences from year to year being primarily the result of variation in climate and in ground water storage at the end of the hydrologic year.

Recently computed high elevation watershed records indicates the relation of consumptive use with elevation was greater than anticipated. (Table 2). The range of P-RO with elevation in Table 2 may be real or apparent or a combination of both. Decreases in consumptive use with increasing elevation are the integrated effect of processes affecting water loss. Vegetation on the high elevations probably intercepts less rainfall and there are more rock faces with no interception than the lower elevations. Effective temperature for evaporation at the higher elevations is less than at the lower elevations. Transpiration should also be less in the high country due to a combination of lower temperature and a shorter growing season. There is also the possibility that difference in storage capacity may be a factor in explaining the values obtained. The high elevations with a shallow soil mantle have less total available water for consumptive use than do the low elevations with deep soils and deep root systems.

Although the differences are probably in the right direction, the magnitude of change due to elevation differences in Table 2 may well be too high. There is a possibility that the Coweeta precipitation net-work underestimates rainfall on the higher elevations due to wind currents and gage locations on and near the ridge tops. Standard U. S. Weather Bureau gages do not measure condensation, and at the higher elevations this may add significantly to effective precipitation for vegetative growth.

Depletion Curves

Several approximation methods have been devised for determining the normal or average depletion curve of a drainage area. The curve is fitted to an exponential type function and the equation constants may be considered as a watershed characteristic. For certain purposes, the curve is a helpful analytical tool in hydrology. It is used in separating out the base flow component in the storm hydrograph. It can be used to derive the discharge-storage relation above a minimum base flow which is valid for determining changes in ground water storage. It has also been suggested that watersheds might be standardized, classified and compared according to the shape of their respective depletion curves.

The question arises whether the normal or average depletion curve is an estimate of a unique characteristic of the drainage area or whether it is an average of many individual curves, each characteristic of the area. If the latter is true, then some caution must be used in applications of the curve. Repeated observations of stream hydrographs during numerous protracted dry periods do not indicate any one definite pattern of ground water depletion, with due allowance made for seasonal and climatic differences.

Several hypotheses have been offered to explain the variation in outflow from storage, none of which seem to take into account an important characteristic of the ground water reservoir. It is not necessarily one large reservoir, but a number of smaller independent units. Each unit, therefore, has its own characteristic depletion curve. The curve of the main drainage is a composite curve which assumes various forms depending on how the individual unit curves synchronize.

Table 2.--Relation of elevation to evapo-transpiration and streamflow
Period 1947 - 1952
(Provisional Table)

Water-shed	Elevation mid-area contour	Temperature Mean-Max. May-Sept.	P-RO			Precipitation			Streamflow		
			Annual	May-Oct.	Nov.-Apr.	Annual	May-Oct.	Nov.-Apr.	Annual	May-Oct.	Nov.-Apr.
	Feet	°F	In.	In.	In.	In.	In.	In.	In.	In.	In.
1	2763	80.4	38.40	20.52	17.88	72.88	33.44	39.44	34.48	12.92	21.56
2	2790	80.4	38.67	22.63	16.04	73.69	33.81	39.88	35.02	11.18	23.84
21	3245	76.2	24.31	17.28	7.03	84.76	37.83	46.93	60.45	20.55	39.90
41	3503	76.2	27.25	20.73	6.52	86.09	40.46	45.63	58.84	19.73	39.11
36	4252	67.9	16.61	17.50	-0.89	93.39	43.78	49.61	76.84	26.28	50.50
37	4260	67.9	19.03	18.44	0.41	94.25	44.39	49.68	75.22	25.95	49.27

Hydrologic Notes

Following a rather warm April, May turned out to be a cool month with later killing frosts. Five frosts occurred later than the average date of the last frost in spring and the 28° F. minimum recorded on the morning of May 22, is the latest frost in 20 years of record at the valley floor.

Ground water well No. 14, our best indicator of movement of the valley water table, commenced to fall on May 6 of this quarter.

Table 3.-- Climatic and Precipitation Summary

	Temperature						Evaporation		Precipitation	
	Average		Maximum		Minimum					
Mo.	1954 °F	Dev.1/ °F	1954 °F	Dev.1/ °F	1954 °F	Dev.1/ °F	1954 In.	Dev.1/ In.	1954 In.	Dev.1/ In.
Apr.	59.0	+4.4	72.7	+4.6	45.2	+4.2	3.42	-0.38	5.05	-0.70
May	56.2	-5.5	70.1	-6.1	42.3	-4.9	3.73	-0.35	3.59	-0.69
June	67.5	-1.5	82.6	+0.2	52.4	-3.2	4.70	+0.59	4.02	-0.66
						Quarterly total			12.66	-2.06
						Water Yr. to June 30			56.10	+6.46
						Cal. Yr. to June 30			40.92	+3.54

1/ Deviation from normal.

Visitors

Nineteen groups with a total of 96 people visited Coweeta during the quarter. In addition, E. F. Brater, Professor of Civil Engineering, University of Michigan, spent the week of June 21 with us. Ernie, an alumnus of the Division of Watershed Management, spent the week revisiting his early work at Coweeta as well as obtaining information and records to be incorporated into a revision of his textbook on hydrology.

Cooperation

N. C. Wildlife Resources Commission

During the past quarter, the cooperating fish biologist completed examination of stomach contents of 241 rainbow trout. The samples studied from trout caught in the September through February period were obtained on the Coweeta and Dryman Fork areas; the remaining samples were largely obtained from the fish management areas in Western North Carolina.

Table 4.--Percentage composition, by two-month periods, of the stomach contents of rainbow trout collected from streams of Western North Carolina.

	January-February	March-April	May-June	July-August	Sept.-October	November-December
Number stomachs	14	67	63	61	19	17
Aquatic food 1/	78.2	79.9	64.7	30.4	37.0	35.7
Aquatic adults	15.8	3.6	8.0	7.8	11.7	4.6
Terrestials	6.0	16.1	27.2	61.5	51.3	59.7
Vertebrates	---	0.4	0.1	0.3	---	---

Aquatic insects constituted the major portion of stomach contents of rainbow trout during the later winter and early spring months from January through June, and surface foods (terrestials) predominated during the summer and fall months. Of the aquatic foods, Diptera and Plecoptera reach a peak in January-February, mayfly nymphs in March-April, and caddis fly larvae during May-June. Crayfish were taken throughout the year but were never of major importance numerically. Including the adults of aquatic insects, the aquatic environment provided as high as 94% of the food and did not fall below 38% in (July-Aug.) the lowest two-month period.

The adults of aquatic insects appear somewhat unusual for January-February with 16% and again September-October with 12%. The January-February high is known to be the result of the February emergence of large numbers of the stonefly, Leuctra sara.

Universities

Jerry G. Williams, working on vegetational changes in the woodland grazing Watershed No. 7 for his dissertation, completed the requirements for the M. S. degree at Michigan State College during the quarter. Jerry expects to be called into military service in July.

Dean Freeland resigned from the Forest Service to accept a position as Assistant Professor on the Forestry Department faculty, Michigan State College. During the next two years, he will be on leave from MSC to allow him to teach in Colombia, S. A., under the technical aid program. Dean spent several weeks at Coweeta during the quarter obtaining soil moisture samples on Watershed No. 17.

Kenneth A. Pitcher, at Coweeta on a cooperative aid project with North Carolina State College, is well into his field sampling and laboratory analyses. He has selected "The Effects of Cove Site Vegetation on Soil. Moisture and Streamflow in the Southern Appalachians" as the subject for his master's thesis.

1/- Primarily larval and nymph stages of insects and a small percentage of mollusks and crayfish.

Publications

Williams, Jerry G. 1954. A study of the effect of grazing upon changes in vegetation on a watershed in the Southern Appalachian Mountains. Thesis for the Degree of M. S., Michigan State College, 138 pp.

Comments and Replies

We have received several comments on previous quarterly reports and wish to thank the technicians who have helped us by their remarks. The following discussion is in reply to comments on a discussion in the October-December, 1953, Quarterly Report on the time variable.

Estimating Treatment Effects with Time Trends - Kovner

The following is supplementary material to the discussion contained in the October-December, 1953, Quarterly Report, pp C-5 to C-7.

In the example selected, a linear time trend was fitted to post-treatment streamflow since the rate of decrease of annual increases appeared to be constant for the period for which data were available. This was based on a plotting of the annual increases for 13 years, as shown in Fig. 3. An estimate of the normal post treatment streamflow is obtained from the calibration period regression. This estimate is subtracted from the corresponding observed streamflow to arrive at the estimated increase due to treatment.

Over a more extended time period or with other experimental treatments it may be more appropriate to assume that the effect of cutting decreases at a decreasing or increasing rate. From graphical plotting of the increase plus professional knowledge, it should be possible to select a relationship which will adequately express such a time trend.

Many different functions of the time variable are available. A few of the more appropriate ones are listed as follows:

$$X_3 = X_2^2;\ X_4 = X_2^3;\ X_5 = X_2^{\frac{1}{2}};\ X_6 = \log X_2;\ X_7 = \frac{1}{X_2}\ ;\ X_8 = \frac{1}{X_2^2}$$

The logarithmic form may be very appropriate in which case the post treatment annual streamflow would be expressed as

$$Y_T = a_o + b_1 x_1 + b_2 \log X_2$$

In cases where the trend reversed itself for a short period, it might be appropriate to use

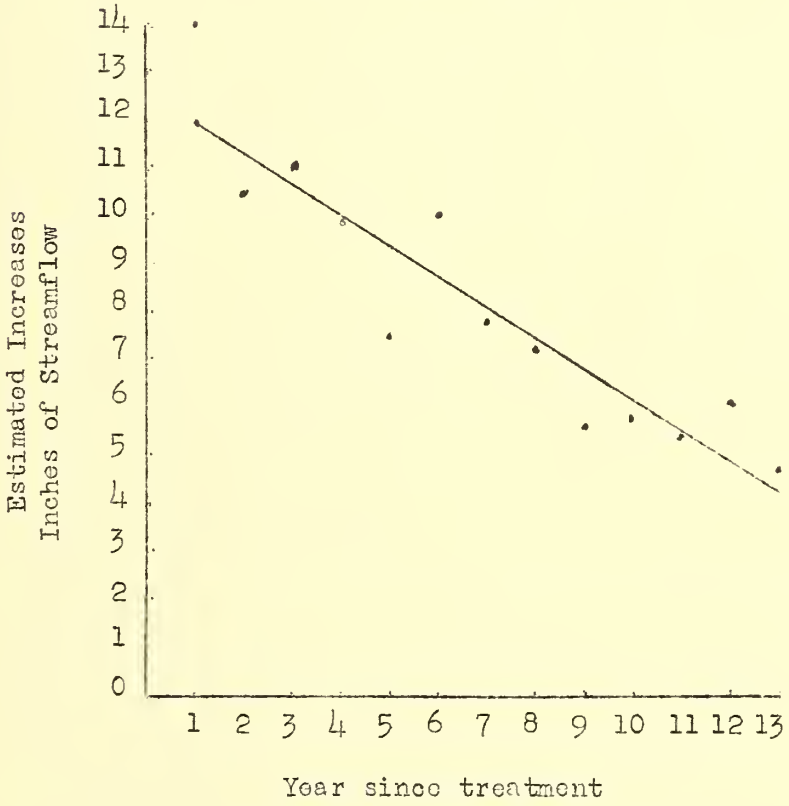
$$Y_T = a_o + b_1 X_1 + b_2 X_2 + b_3 X_2^2 + b_4 X_2^3$$

Up to this point it has been assumed that the relation between Y and X_1 is independent of time. Normally, we would expect this to be true, even following cutting. There is the possibility for some treatments that time enters into this relation, in which case it would be necessary to introduce the joint function of X_1 and X_2. We would then have to deal with an expression such as

$$Y_T = b_o + b_1X_1 + b_2X_2 + b_3X_1X_2$$

in the linear form and corresponding regressions for other functions of X_2 as indicated previously

Fig. 3.--Estimated annual increases in streamflow from W.S. No.13 following treatment.



Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
April - June 1954

PIEDMONT RESEARCH CENTER 1/

Climate

In general this quarter was hot and dry. The rain in June was the lowest recorded for that month and next to the lowest amount measured for any month since records began on the Calhoun. The 106°F. maximum in June is second highest temperature recorded here. In July, 1952, 108°F. maximum was recorded.

Climatic Summary - Calhoun Experimental Forest

Month	Average temperatures: Max.	Min.	Mean:	Highest: Temp.	Lowest: Temp.	No. of days: with rain	Precip.	Evap.
	°F.	°F.	°F.	°F.	°F.		Inches	Inches
April	77	50	63	90	30	9	2.40	4.97
May	77	50	63	90	34	7	3.32	5.28
June	92	61	76	106	44	6	.62	7.62

Practically all of the technical time this quarter was spent on a problem analysis for the Piedmont Research Center Territory, and the compilation of a bibliography on shortleaf pine. Some time was spent in analyzing soil samples and in making a reconnaissance survey of vegetation on the Calhoun Experimental Forest. No new studies were started this quarter.

Calhoun Forest Reconnaissance

Last fall it became apparent that a reconnaissance of the forest types and age classes on the Calhoun Experimental Forest would be necessary before any plans could be made for studies of silvicultural systems. It was decided that such a reconnaissance would be made and a forest type map prepared for the area. This work was completed during April.

The condition classes used were the same as those used by the South Carolina National Forest. The minimum size of any condition class mapped was 20 acres, with the exception of old fields which were mapped down to 5 acres. The following table shows the distribution of condition classes on the Calhoun Experimental Forest by acreage and percent.

1/ Joint projects of the Divisions of Watershed Management and Forest Management

Distribution of Forest Condition Classes
Calhoun Experimental Forest - 1954

Condition Class	Acreage	Percent
Administrative sites	10	0.1
Non-stocked old field	359	3.2
0-20 Year-old pine - healthy	583	5.1
21-40 Year-old pine - healthy	85	0.7
41-60 Year-old pine - healthy	10	0.1
Littleleaf diseased pine	7,369	65.0
Hardwoods - young stands	1,642	14.5
Hardwoods - sawtimber stands	1,214	10.7
Cultivated land	65	0.6
Total	11,337	100.0

In classifying the forest stands, a stand that showed any signs of littleleaf disease at all was classified as a littleleaf diseased stand. The reason for this is that a littleleaf stand is heterogeneous as to age and size and cannot be easily classified into even-aged classes. The table shows that 65 percent of the area is within this littleleaf condition class. This figure is high because it includes stands with light littleleaf; i.e., stands with only an occasional diseased tree. Of the 7369 acres in the littleleaf condition class, 46 percent is light littleleaf, 46 percent moderate littleleaf, and 8 percent severe littleleaf.

Healthy pine stands comprise only 6 percent of the total area and the major portion of this is in the 0-20 year age class. Hardwoods comprise 25 percent of the area. This includes both upland and bottomland hardwoods but most of it is bottomland.

General

In early April the staff of the Center met with Hepting, Evans, and Hursh for a program conference. Past, present, and future work was discussed and priorities were set up for the utilization of technical time during the next year.

On June 10-11 we had the third annual meeting of the Center's Advisory Committee. The members on the original committee were listed in the January-March, 1952 Quarterly Report. Since that time the following individuals have been added to the Committee:

John C. Billingsley, Consulting Forester, 924 Fair Street, Newberry, South Carolina
F. H. Claridge, State Forester, Box 2719, Raleigh, North Carolina.
N. B. Goebel, Associate Forester, Department of Botany, Clemson College, Clemson, South Carolina
J. L. Gray, Extension Forester, N. C. State College, Raleigh, North Carolina.

Publications

Olson, D. F., Jr., and M. D. Hoover. Methods of soil moisture determination under field conditions. Station Paper No. 38. April 1954.

This paper describes in general the various ways soil moisture can be determined in the field. It also describes in some detail the methods used at the Piedmont Research Center.

Hoover, M. D., Metz, L. J., and D. F. Olson, Jr. Soil sampling for pore space and percolation. Station Paper No. 42. June 1954.

This paper describes in detail methods for sampling soil for pore space and percolation data. It discusses field sampling, laboratory analysis, and computational methods, as used at the Piedmont Research Center.

Personnel

O. L. Copeland, Jr. transferred from the Center in April. He is now located at the Inland Empire Research Center, 157 South Howard Street, Spokane 4, Washington. He is working on the pole blight disease of western white pine.

Visitors

V. L. Harper and P. B. Hinkelman, Washington Office; C. S. Herrick, Jr., R-8 Office; C. T. Martin, Civil Service Commission, Atlanta; Dennon, Ostrom, Evans, Hepting, Hursh, Anderson, and Smith, Asheville Office.

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
July - September 1954

DIVISION OF WATERSHED MANAGEMENT RESEARCH

SUMMARY

Page

Coweeta Hydrologic Laboratory

New Chemicals for Treating Public Water Supplies offer enhanced opportunity for multiple use of municipal watersheds.. H-1

Latest Progress Report on the amount of rain caught in tilted and vertical gages indicates that for Coweeta conditions vertical gages generally catch more rainfall..... H-2

Kovner presents a simple method to determine long-time rainfall and runoff values for a Coweeta watershed. H-3

Discussion of an AGU article, Effect of a Hardwood Forest Canopy on Rainfall Intensities, suggests that some of the data are at variance with previously published results..... H-10

Piedmont Research Center

Study of shortleaf seed production expanded to include 8 stands in four locations..... H-15

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
July - September 1954

DIVISION OF WATERSHED MANAGEMENT RESEARCH

COWEETA HYDROLOGIC LABORATORY

New Chemicals for Treating Public Water Supplies

Use of chlorine for killing pathogenic bacteria is regarded as a major factor in reducing diseases transmitted in public water supplies. Its wide acceptance has been favored by the small quantities of chlorine needed and by the low cost. However, the germicidal action of chlorine is not thoroughly understood despite its wide acceptance and use, although there are various theories why chlorine is toxic to bacteria in ways other than by oxidation.

Organic matter in water reacts with and utilizes chlorine which reduces its germicidal properties. Thus any disturbance on a watershed that increases organic matter in the stream requires greater concentrations of chlorine and a longer contact period to insure bacterial kill. If there is an increase in organic matter and sediments requiring increased use of chlorine compounds, there is likelihood of water having an unpleasant taste and objectionable odor.

To provide the greatest margin of safety for public water supplies the Public Health officials follow the principle of multiple barriers: (1) a protected pure water supply and (2) a treatment process. The mountain areas of the Eastern United States have many municipal watersheds, some of which are on National Forests. Attempts to sell timber, place stands under management, or permit multiple use on these watersheds have been difficult because of rigid requirements of local boards of Public Health. Part of the difficulty associated with completely protected watersheds is the lack of large-scale demonstrations to show that logging has not altered water quality. Another is the limited germicidal properties of chlorine compounds used by various communities in the eastern mountains.

New developments in water treatment have produced chemicals that are up to 14 times more effective in killing pathogenic bacteria than those commonly used by many communities. Hypochlorous acid and chlorine dioxide are two of the more effective agents. The cost for some of these newer agents may be less than chlorine, in addition to providing a simplified control procedure in the treating plant. With the more powerful chemicals available land managers have better reason to question some of the rigid specifications that now preclude multiple use on municipal watersheds.

It is suggested that foresters preparing timber sale agreements for municipal watersheds recommend that public water supplies be treated with the new and more effective chemicals during the period that contamination is most likely to occur.

Vertical and Tilted Rain Gages

There were no consistent differences between the behavior of the vertical and tilted gages as reported in the January-March 1954 Quarterly Report. The data from additional storms recorded since March indicate that for Coweeta conditions the vertical gages generally catch more rain than the tilted gages (Table 1).

Table 1.--Comparison of total precipitation recorded in vertical and tilted gages for 20 storms.

Storm Class	Gage No. 70		Gage No. 61		Gage No. 69		Gage No. 2		Gage No. 54	
	Tilted Gage	Diff. V-T	Tilted Gage	Diff. V-T	Tilted Gage	Diff. V-T	Tilted Gage	Diff. V-T	Tilted Gage	Diff. V-T
Inches	Inches	Per cent	Inches	Per-cent	Inches	Per-cent	Inches	Per cent	Inches	Per cent
0 -0.50	1.22	+3.3	0.91	+2.2	1.28	+ 4.7	0.79	+ 5.1	1.13	+12.4
0.51-1.00	3.46	+0.6	6.52	+4.4	6.16	+11.3	5.85	+10.4	5.89	+10.5
1.01-1.75	4.38	+1.6	3.37	+3.6	5.03	+ 0.6	4.97	+ 1.4	8.00	+ 6.1
1.76-plus	7.30	-3.4	14.02	0.0	9.41	0.0	12.43	+ 0.9	10.79	+ 1.1
Total	16.36	-0.7	24.82	+1.6	21.88	+ 3.9	24.04	+ 3.5	25.81	+ 5.3

Table 1 indicates that for storms over one inch the gages are in close agreement. For storms less than one inch the differences are more striking. For 15 of the 20 storms measured the vertical gage storm total exceeded the tilted gage. Since the gages were selected to represent a wide range in elevation and aspect the results are surprisingly consistent. Some of the variability is probably due to the fact that Gages No. 70, 61 and 69 are located on topographic facets, whereas Gages 2 and 54 are mounted on prominent ridges. The difference in total catch, however, amounts to less than five percent.

It would be expected that the vertical gage would catch more rain than the tilted gage when they are located on the leeward side with respect to storm direction. Since no instruments are operating for indicating storm direction it is impossible at this time to safely assign recorded differences to this phenomenon.

Determination of Long-Time Rainfall-Runoff Values for a Coweeta Watershed

Small watershed rainfall-runoff records have been collected at Coweeta for 19 years beginning in 1935. Although the data are complete and accurate, they are for a relatively short period from a climatological point of view and hardly adequate as a basis for establishing normal and extreme events. For this purpose a period of 50 years is required as the usual minimum. Long-time precipitation records, 1879-1952, are available at the Highlands, N. C., station which is about 15 miles east of Coweeta. The precipitation data at Highlands for 1935-1952 can be compared with the long-time record and also with that for a Coweeta watershed. As shown below, certain relationships are established which make it possible to extrapolate the Coweeta data to cover a 70-year period. Finally, from the known relation between rainfall and runoff on the watershed the long-time characteristics of the extreme values can be estimated.

Table 2 provides a comparison of the 1935-1952 precipitation at Highlands with the 1879-1952 precipitation.

Table 2.--Comparison of short- and long-time monthly averages of precipitation, Highlands, N. C.

Month	Period		Difference
	1935-1952	1879-1952 1/	
	Inches	Inches	Inches
Jan.	7.71	7.07	+ 0.64
Feb.	6.44	7.07	- 0.63
Mar.	8.27	7.96	+ 0.31
Apr.	5.82	6.23	- 0.41
May	4.54	5.22	- 0.68
June	6.09	6.87	- 0.78
July	9.92	8.46	+ 1.46
Aug.	8.43	7.39	+ 1.04
Sept.	5.41	6.07	- 0.66
Oct.	4.55	5.35	- 0.80
Nov.	5.65	5.48	+ 0.17
Dec.	6.78	7.50	- 0.72
Annual	79.61	80.67	- 1.06

1/ There are a few missing records during the early part of this period. Checking against rainfall data from another nearby station at Clayton, Georgia, indicates it does not affect this special analysis.

The short- and long-time monthly averages are in very close agreement. As a further comparison, a similar analysis for Clayton, Georgia, produced average annual totals of 67.58 for 1935-1952 and 69.28 for the long-time period. The 1935-52 average annual precipitation on Coweeta watershed No. 2 is 68.24 inches. Based on the relationships at Highlands and Clayton we can estimate the long-time average of watershed No. 2 as 69.50 inches.

Interesting information on the behavior of extreme rainfall values can now be derived as shown in the following graphs. Maximum and minimum values are obtained for a number of consecutive months up to three years and are then expressed as a percentage of the long-time average. Ordinarily, climatic extremes increase in severity with time. For example, in Figure 1 the wettest periods during 1935-1953 at Highlands fall considerably short of those during the 1879-1952 period. The driest extremes are not so divergent and, in fact, are in close agreement through the first 19-month period.

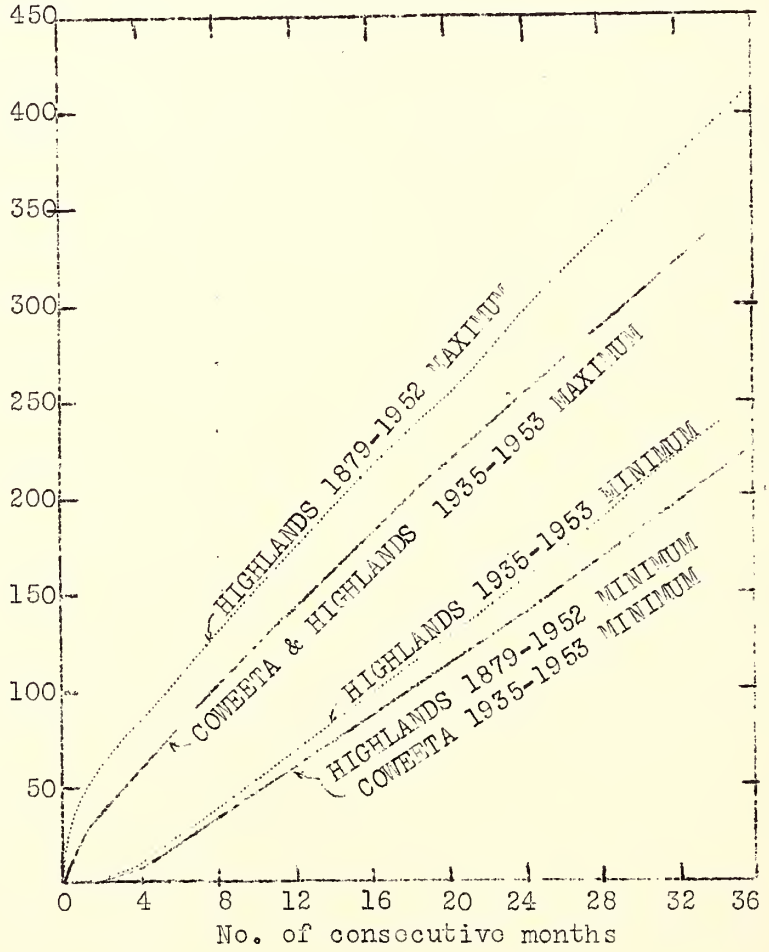


Figure 1.--Reliability of rainfall, Coweeta and Highlands, N. C.

As should be expected, the short time maximums for Highlands and Coweeta are practically identical and are traced as one curve. This does not hold true for the minimum values where we find the Coweeta curve coincides with the long-time curve for Highlands. This peculiarity is not unreasonable as most of the divergence in Highlands 1935-1953 minimum curve is due to a few very large summer rains which often occur locally in the mountainous topography.

Based on data in Figure 1, an attempt has been made to estimate the long-time maximum and minimum runoff from Coweeta watershed No. 2 and is presented in Figure No. 2. No runoff data are available for Highlands. Maximum runoff from the Coweeta watershed approximates one-half of the maximum precipitation, and minimum runoff one-third of the minimum precipitation. Applying the corresponding adjustments in the short-time runoff curves for watershed No. 2, we estimate the long-time values for this watershed. The runoff curves are necessarily S-shaped due to the alternating of high and low flows in the dormant and growing seasons.

Examining the runoff curves it is apparent that periods of higher streamflow may be expected in the future as compared with past records. Not much change is expected in minimum flow.

Many water users are interested in the minimum flows that might be expected for varying time intervals. From the curve "Estimated minimum for a 70-year period" in Figure 2 it is possible to estimate reliable streamflow on watershed No. 2 and the storage requirements needed during the expected three lowest years of runoff. We find that in Figure 3 the reliable water yield is 57 percent of the estimated long-time precipitation average of 69.50 inches and multiplying gives 39.61 inches of runoff for a three-year period, or 13.20 inches per year. The dashed line represents a uniform runoff of 30,000 gallons per day from the 30.78-acre watershed. The greatest deficit occurs at 30 months and is represented by the vertical line. This deficit is 9 percent of 69.50 inches, or 6.26 inches, that is equivalent of 5,200,000 gallons or a 173-day supply. This is a phenomenon that is expected to occur roughly once in 70 years, assuming a rate of runoff amounts to 13.20 inches per year for a three-year period.

It is recognized that this is a simple method for estimating water yields and storage requirements as contrasted with the much more complex and detailed statistical methods that have been devised for solving this problem. However, where long-time precipitation and runoff records are not available, some kind of an approximation is required, and for such situations this simple approach may be helpful.

Figure 2

RELIABILITY OF RUNOFF W.S. No. 2
1935-1952

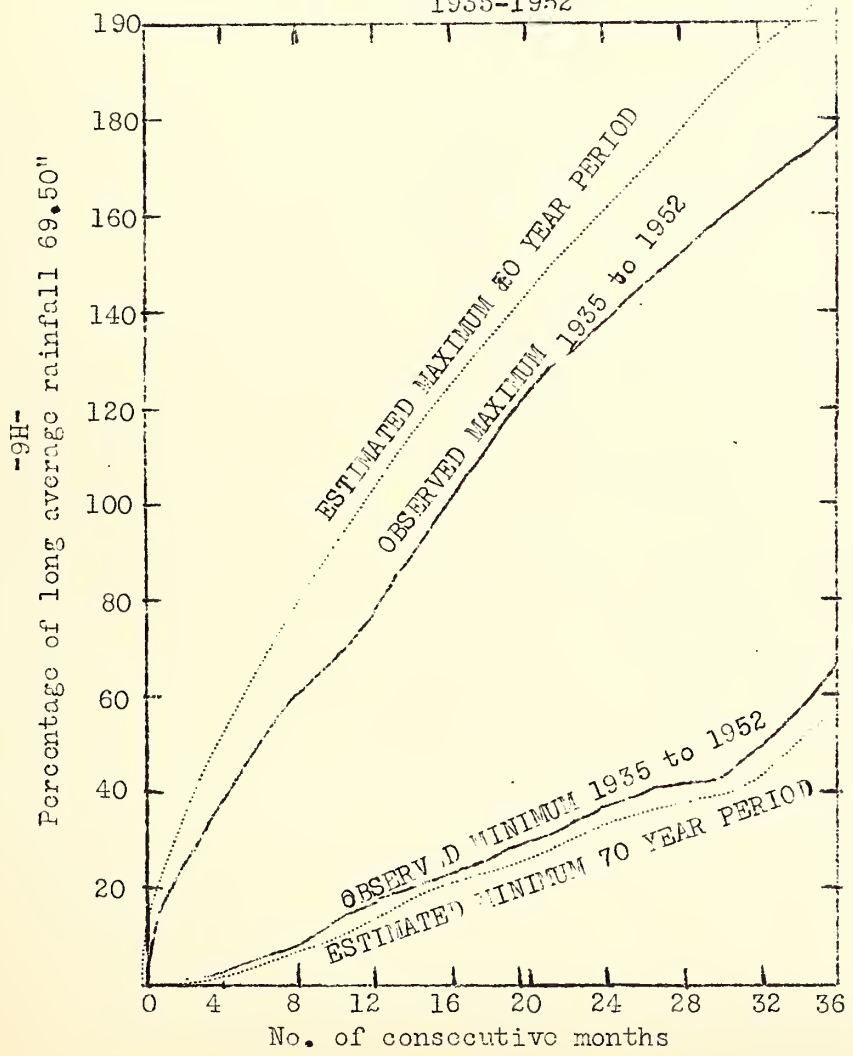
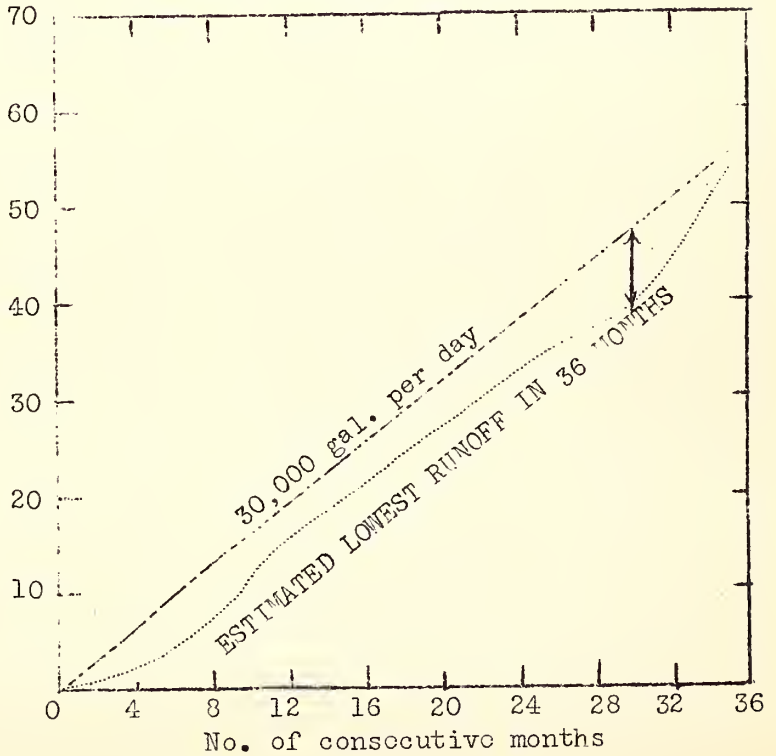


Figure 3

STORAGE REQUIREMENTS BASED ON THREE YEAR ESTIMATED MINIMUM RUNOFF FOR CONSECUTIVE MONTHS FROM W.S. No. 2



Hydrologic Notes

The quarterly total of 9.76 inches (Table 3) is the lowest third quarter precipitation in twenty years of Coweeta records and 59 percent of the expected normal rainfall. The accumulated yearly totals that showed excesses as of June 30 had changed to deficits by September 30. Countywise the deficiency in rainfall is greater than that indicated by the Coweeta gages since the Laboratory experienced some very local rains from April thru September that did not occur elsewhere. Franklin, N. C., for example, only ten miles north of Coweeta, experienced drought conditions in the first part of July. The shortages in rainfall have produced corresponding deficiencies in soil moisture, ground water and streamflow.

Table 3.--Quarterly precipitation summary

Month (1954)	Precipitation	Deviation from normal	No. of Storms	Deviation from normal
	Inches	Inches		Inches
July	5.74	-0.77	12	-4
Aug.	2.94	-2.80	8	-7
Sept.	1.08	-3.23	3	-6
Quarterly Total	9.76	-6.80	23	-17
Water Yr. to 9/30	64.76	-1.12		
Cal. Yr. to 9/30	50.68	-2.84		

Maximum temperatures for the quarter (Table 4) were considerably higher than normal and the summer will be remembered as hot and dry both by local residents and summer visitors. Maximum temperatures in excess of 90°F. were recorded during the first week in September. Pan evaporation was near normal in July and August but increased to a new record in September with 1.21 inches above normal.

Table 4.--Climatic summary of air temperatures and evaporation

Month	Average		Maximum		Minimum		Pan evaporation	
	1954	Deviation from normal	1954	Deviation from normal	1954	Deviation from normal	1954	Deviation from normal
	°F	°F	°F	°F	°F	°F	Inches	Inches
July	72.6	+1.8	86.2	+2.9	59.0	+0.7	4.54	+0.38
Aug.	71.4	+1.0	85.4	+2.4	57.3	-0.5	3.84	+0.08
Sept.	66.4	+1.5	84.3	+5.5	48.6	-2.5	4.41	+1.21
Aver.	70.2	+1.4	85.3	+3.6	55.0	-0.8	4.26	+0.56

Soil Moisture and Ground Water

Comparative soil moisture measurements which might indicate severity of this drought are not available, but the vegetation affords one index. Late corn and bean plantings--normally successful--were complete failures. Foliage over large acreages of forest land have turned brown for lack of moisture. Such areas are prevalent on the steeper slopes where soils are shallow and sandy and were rock outcrops occur. Locally the people refer to the drought of 1925 as being the worst within memory. In 1925 drought effects on vegetation were more pronounced than conditions this year due to the fact that it occurred earlier in the growing season.

Water tables have reached record lows this year. Springs which held up in 1925 had ceased to flow by the end of September. Highlands, N. C., one of the wettest areas in the eastern United States has experienced a water shortage and will have to tap additional ground water supplies.

The best evidence of lowered water tables is reflected in minimum stream discharges. Streamflow at Coweeta had reached record 20-year minimums at the end of the quarter. Table 5 shows some instantaneous minimum flows on watersheds with varying mean elevations.

Table 5.--Minimum instantaneous flows

Watershed	Mean elevation	Discharge
	Feet	c.s.m.
2	2827	.102
22	3435	.375
27	4155	.218
37	4345	.381

These values are in line with state and regional conditions. State Geologists of North Carolina and Georgia report that lower flows are being recorded on many watersheds than ever occurred during the 1925 drought period.

Comparison of these new records for minimum flow with maximum storm flows illustrates the variability of water supplies for municipal, recreation, industrial or power uses. Maximum recorded flows have averaged 1400 times greater than the minimum flows and show the task is not an easy one in regulating water supplies in the eastern mountains. To provide for a fairly uniform demand during these periods of low rainfall, generally large reservoir capacities or reserve watersheds are needed. With these record low flows several communities in the Southeast that did not have adequate reserve capacities are experiencing water shortages during this drought.

Cooperation

Universities

Kenneth Pitcher, graduate student in Forestry has completed the field work for his Masters thesis and returned to N. C. State College September 10.

Mohammed Said Katana, also a forestry graduate student at N. C. State College spent approximately six weeks at Coweeta. Most of the time was devoted to processing collected hydrologic records for a Masters thesis titled "Rainfall-runoff relations on a forested, a grass, and a bare watershed in the Copper Basin, Tennessee.

Bryant Cunningham, forestry aide at Coweeta and cooperative forestry student at Cullowhee, returned to the college for the fall semester.

Personnel

Tom Nelson has been transferred back to the Division of Forest Management and reassigned to the Georgia Hardwood Utilization Project as Project Leader Silviculturist.

Daniel (Dub) Nichols has been shifted from Coweeta to the Asheville Office as Chief Fiscal Control Officer.

Visitors

There was a heavy visitor load this quarter, averaging more than 2 organized groups per week. The 26 groups totaling 189 visitors included 4 groups from universities, two groups of State District Foresters, and four foreign visitors.

A two-day training session in watershed management was conducted for a group of Virginia State Foresters. The Virginia Foresters are starting to prepare logging plans for several municipal watersheds. The Coweeta staff found their visit stimulating because of the many problems the District Foresters presented that they had encountered in preparing watershed management plans for the municipal watersheds.

The GII inspection team of Cliff and Josephson visited Coweeta on Friday morning, September 25.

Publications

Kovner, J. L., and Evans, T.
A method for determining the minimum duration of watershed experiments, Trans. Amer. Geophys. Union, Vol. 35, No. 4, pp 608-612, August 1954.

Discussion

Effect of a Hardwood Forest Canopy on Rainfall Intensities, by G. R. Trimble, Jr. and S. Weitzman, Trans. A.G.U, V. 35, pp 226-234, 1954.

The authors do not appear to be concerned that some of their data are at variance with all previously published data, a fact which casts an unhappy light on the rest of the article. Kittredge (1948), for example, states that "the variation with season in the deciduous species between winter and summer obviously is associated with their loss of foliage and also with reduced evaporation, and the (canopy) interception is therefore lower in the winter." Several examples indicate a very significant difference. From item (4) and Figure 7 (p. 231), we find that winter and summer canopy interception are approximately the same; actually, the former is slightly greater. Certainly Figures 3 and 4 in the text do not show any peculiarities in the stand canopy which would contribute to this unique result. Yet (p. 232) we read, "It is obvious that a tree in full leaf offers greater intercepting surface to rainfall than does the bare tree in winter."

The study suffers from some obvious defects. Five gages at fixed positions and 59 storms cannot provide reliable average figures for interception phenomena. Kittredge (1948) states, "The range of the differences in percentage interception in different positions under the crowns in a forest stand is so wide that a large number of records of rainfall would be required even in a limited area to arrive at a reliable average figure for interception over any given area of forest." Figures 6, 7 and 8 (p. 231), based on the

maximums listed in Table 1, contain some extensive and unwarranted extrapolation. For example, the 15-minute winter maximum is only 1.08 in./hr., although the curves are extended through 3.00 in./hr. The winter percentage reduction curves in Figure 8 are practically a horizontal straight line which is hardly in agreement with fact or theory. In addition, one suspects that the higher intensities are poorly represented in only 59 storms. Furthermore, the recording rain gage with an 8-inch opening has obvious limitations in sampling precipitation under a forest canopy. Wilm (1945) has suggested a method for improving the sampling with a limited number of such gages by moving them between storms.

For illustrative purposes, in Table 6 data are given from an interception study of total rainfall at the Coweeta Hydrologic Laboratory under an even-aged hardwood stand about 40 years old. Over a four-year period 100 summer and 270 winter storms were sampled. The extreme variability by storm size, season, and location is exhibited as well as the fact that for individual gages the reduction effect can be much greater in the winter than in the summer. It is evident that extremely erratic and contrary results may be obtained where only a few gages are used. No mention is made regarding the consistency of the individual gages in the seasonal relationship (p.228).

In view of the above, it is idle to speculate on the reasons why the summer canopy shows less reducing effect on high intensity rainfall than the winter canopy (p.232).

There is need for some minor corrections as follows:

1. The statement is made that the rate of interception is the reciprocal of ground rainfall intensity (p.232). Evidently, the authors have in mind the obvious and correct relation that intensity in the open minus the intensity intercepted by the canopy equals the ground rainfall intensity.

2. The regression equations (p. 229) include a very small standard error considering the large coefficients of variation indicated in Table 6. It seems that the variance of the individual storm intensity averages has not been included in this error term.

It is difficult to go along with the main conclusion of the authors that the physical presence of a forest cover has "only a limited value in reducing the erosion potential of rainfall as it strikes the forest floor." It must be assumed that this language means a very small effect; otherwise the statement is obviously true, but of no particular significance. On the other hand the figures show an average 18 percent reduction in the 15-minute winter rainfall intensity. It is doubtful that this could be regarded as of small effect in reducing actual erosion.

Table 6.--Canopy interception of total rainfall
(Barkers Cove Study, Coweeta Hydrologic Laboratory)

Rainfall amt by class	Gage No. 14 Percent intercepted		Gage No. 12 Percent intercepted	
	Winter	Summer	Winter	Summer
Inches				
.01 - .10	25.6	39.9	30.0	68.6
.11 - .20	20.7	17.5	15.9	35.7
.21 - .30	59.0	12.5	4.2	30.8
.31 - .50	10.4	6.5	4.1	29.0
.51 - .75	25.0	10.4	9.9	22.4
.76 -1.00	19.2	8.6	11.4	23.2
1.01 - 1.50	22.9	5.5	7.4	18.6
1.51 - 2.00	19.8	4.5	6.4	24.8
2.01 -	21.7	6.6	3.6	17.8

The following facts should be given consideration if the erosion potential is brought into the discussion:

1. It is emphasized that the forest canopy tends to concentrate small droplets into larger drops. No mention is made that the canopy also has the reverse effect of splitting up larger drops associated with high rainfall intensities, Chapman (1948).

2. The upland hardwood forest of the eastern United States generally has a low ground cover of herbaceous and shrub vegetation. Moreover, Figure 3 illustrates that reproduction is fairly dense with many tolerant species present. Accordingly, there are very few stands where the space between the ground and the dominant canopy is not occupied by some kind of vegetation which is effective in reducing the terminal velocity of raindrops, particularly for the high intensity cloud bursts which occur during the summer.

3. The terminal velocity of wind-driven rain in the open, particularly on steep slopes, may greatly exceed the terminal velocities usually reported. Forest cover is highly effective in reducing the wind velocity to negligible force.

4. The pattern of rainfall intensity under a good forest canopy is locally extremely variable. Under ordinary field conditions this would not produce the same degree of erosion as the higher uniform intensity in the open.

It is felt the authors should have restricted themselves to the limitations of their data which only established some interesting observations on the effect of canopy interception upon rainfall intensity. The introduction of the term "erosion potential" is felt to be unfortunate even though it serves to enhance the scope of the study. Other more complex studies must be devised to evaluate the effect of the canopy in reducing erosion.

Kittredge, J. Forest Influences, McGraw Hill, 1948.

Wilm, H. G. Determination of Net Rainfall, Jour. Agr. Research, 1945.

Chapman, Gordon Size of Raindrops and Their Striking Force at the Soil Surface in a Red Pine Plantation, Trans. Amer. Geophys. Union, V. 29, pp 664-670, 1948.

PIEDMONT RESEARCH CENTER[1/]

July - September 1954

As with the rest of the nation, this past quarter has been very dry. Practically all small streams are dry, many of them for the first time in the memory of local residents. According to the S. C. Climatological Data, June and July combined were the driest since records began in 1887. Many pines have been dying on the Calhoun Experimental Forest the past several months. Inspection showed the trees were free of beetles and it was noted that most dead trees were on our most shallow and impermeable soils. Most species of hardwoods are showing premature coloring of foliage, and leaf fall.

Quarterly Climatic Summary - Calhoun Experimental Forest

Month	Average temperatures: Max.	Min.	Mean:	Highest: Temp.	Lowest: Temp.	No.of days: with rain	Precip.	Evap.
	°F	°F	°F	°F	°F		Inches	Inches
July	94	67	80	103	58	8	3.97	7.98
August	95	66	80	107	59	6	2.18	7.22
September	91	59	75	102	44	1	0.01	6.43

Shortleaf Pine Seed Production

Last year a study was installed to determine the amount and quality of seed produced by several stands of shortleaf pine and the periodicity of seed production over a period of several years. The first year's results appeared in the January-March quarterly progress report.

This year the study was expanded from the original three stands to include eight stands in four locations. Ten 1/4-milacre paperboard seed traps were installed in each of two stands at the following locations: Morganton, N. C.; Union, S. C.; and Athens, Ga. Thus there are 80 seed traps in the field.

The seed will be collected at weekly intervals. A 1/4-acre plot will be established in each stand on which the height, age, and diameter of all trees will be tallied in order to characterize the stand.

Last year's results indicated a poor seed year for shortleaf pine. Present indications are that this year's seed crop will be better than last year's, but to what extent we cannot say.

1/ Joint projects of the Divisions of Watershed Management and Forest Management

Tree Growth During 1953 and 1954

In conjunction with the soil moisture project, height growth has been measured on 6 trees, and radial growth on 5 other trees, during the past two growing seasons.

Table 1.--Height and growth of sample trees

Age of tree	Species	Initial height	Growth 1953	Growth 1954
Years		Feet	Feet	Feet
27	Shortleaf	32.70	1.60	1.05
21	"	32.40	2.15	0.95
30	"	42.70	2.45	1.40
28	"	40.70	1.60	1.30
33	"	37.80	1.00	1.00
32	"	41.50	1.20	0.50

In 1953 height growth began during the last week of March and ended during the latter half of August. This year height growth began around mid-April and ended the first of August.

In both years the radial growth commenced somewhat sooner than the height growth. During the 1953 growing season radial growth began the last week of February and ended the middle of September. This year's growth began around the middle of March and ended in the middle of July. This early cessation of growth is undoubtedly a result of this year's drought.

Table 2.--Radial growth of sample trees

Species	Age	1953		1954	
		Radial growth	Diameter growth	Radial growth	Diameter growth
		mm.	mm.	mm.	mm.
Loblolly (2 trees)	14	3.09	6.18	2.04	4.08
Shortleaf (2 trees)	34	2.21	4.42	1.78	3.56
Shortleaf (1 tree)	27	3.08	6.16	2.70	5.40

Redbud Plantings

The redbud plantings (Quarterly Report, January-March 1954) were checked for survival twice since planted. In May there was practically 100 percent survival at all planting sites. About the first of September another check was made and the survival was still over 90 percent except at two sites. One of these was beneath a forest stand and the other in an old field, both on Wilkes soil. The Wilkes series, one of the poorest soils of the Piedmont, has a thin layer of heavy clay over disintegrated rock, or disintegrated rock right to the surface.

Publications

Metz, L. J. Forest floor in the Piedmont Region of South Carolina. Soil Science Society of America Proceedings, 18(3) :335-338, July, 1954.

This paper gives the annual litter fall, weight of forest floor, and organic matter incorporation in the surface foot of mineral soil for pine, pine-hardwood, and hardwood stands in the South Carolina Piedmont.

General

Much time was spent this quarter in reconnaissance work looking for sites to test littleleaf cutting practices, shortleaf stands for contemplated growing space study, and barren areas for tests of soil rehabilitation methods.

R. G. McAlpine, Jr. transferred from the Center in August. He is now located at the Research Center in Athens, Georgia.

E. L. Brown spent seven weeks on special detail to the Fraser Experimental Forest, Fraser Colorado.

Florencio Asiddao of the Phillipine Forest Service, spent one week on the Calhoun Experimental Forest.

SEMI-ANNUAL REPORT
Forest Influences Research
Southern Forest Experiment Station

April - September 1954

Vicksburg Infiltration Project

The Vicksburg Infiltration Project was started in 1951 at the request of the U. S. Army Engineers who desired development of methods for the prediction of soil moisture. This information was needed in connection with their study of the relation of various soil factors to soil strength which has a strong influence on the movement of military vehicles. The project is headquartered at the Waterways Experiment Station.

A four-volume progress report giving the results of the first two years' effort is soon to be released to the Stations, but this report will not be given general distribution. This report discusses in detail the method used in the prediction of soil moisture and presents accretion and depletion relations for a variety of sites throughout the United States. This early work showed the feasibility of prediction of soil moisture even though it pointed out many weaknesses of the original data.

Since the preparation of this report, the Project has increased its efforts to cover a wider variety of soils and sites. Intensive field work was done in 1953 and early 1954 in several states (Wisconsin, Colorado, Idaho, Arkansas, and New Mexico). These studies further demonstrated the effectiveness of the method of moisture prediction and pointed out the desirability of a survey to cover the major soil classes in the United States and to include permafrost measurements in Alaska.

Four survey crews are now collecting soil moisture and strength data. One survey crew is headquartered at Vicksburg and covers a wide variety of soil and sites in six southern states. Other survey crews are working at the Lake States, Northeastern, and Intermountain Stations. A two-man crew is collecting data in Alaska.

Publications prepared by Project members include:

1. Soil Moisture Measurement With the Fiberglas Instrument. Occasional Paper 128, SFES, 1953. Includes the following papers:

    Comparison of four types of electrical resistance instruments for measuring soil moisture. E. H. Palpant and H. W. Lull.

    An inserter for fiberglas soil-moisture units. E. H. Palpant.

Switch shelters for use with soil-moisture units. E. H. Palpant, J. L. Thames, and A. E. Helmers.

Moisture equilibrium in natural cores during laboratory calibration of fiberglas soil-moisture units. C. A. Carlson.

Installation and field calibration of fiberglas soil-moisture units. K. G. Reinhart.

2. Evapo-transpiration: Excerpts from Selected References. Occasional Paper 131, SFES, 1953. Howard W. Lull.

3. Moisture in Hardwood Forest Floor. W. M. Broadfoot. In Southern Forestry Notes No. 85. 1953.

4. Infiltration on a Timber and a Burn Site in Northern Idaho. J. C. Holland. Research Note No. 127, Northern Rocky Mountain Forest and Range Experiment Station, 1953.

5. Properties Affecting Water Relations and Management of 14 Mississippi Soils. W. M. Broadfoot and W. A. Raney. Mississippi State College, Agricultural Experiment Station, Bulletin 521, 1954.

6. Some Field, Laboratory, and Office Procedures for Soil-Moisture Measurement. Occasional Paper 135, SFES, 1954. Includes the following papers:

Procedures and equipment for determining soil bulk density. W. M. Broadfoot.

Relation of soil bulk density to moisture content as it affects soil-moisture records. K. G. Reinhart.

Core vs. bulk samples in soil-moisture tension analysis. W. M. Broadfoot.

Devices to facilitate King-tube soil-moisture sampling. Edwin R. Ferguson and William B. Duke.

Terminal panel for electrical soil-moisture instruments. B. D. Doss and W. M. Broadfoot.

Phone-jack terminals for soil-moisture units. Frank Woods and Walt Hopkins.

Comparision of laboratory and field calibration of fiberglas moisture units. Charles A. Carlson.

A core method for determining the amount and extent of small roots. Charles A. Carlson.

Publications in preparation include:

1. Infiltration and available water storage capacity in the soil. K. G. Reinhart and R. E. Taylor. Scheduled for publication in October 1954, Trans. American Geophys. Union.

2. The field maximum moisture content. C. A. Carlson and R. S. Pierce. Accepted for publication in Proc., Soil Sci. Soc. of America.

3. Soil-moisture measurement. H. W. Lull and K. G. Reinhart. Planned for publication as Occasional Paper, SFES.

4. Field tests of nuclear instruments for the measurement of soil-moisture and density. E. S. Rush and K. G. Reinhart. Accepted for publication as Miscellaneous Paper, Waterways Experiment Station, Corps of Engineers.

5. Soil moisture regime in some forest and non-forest sites in northern Wisconsin. J. L. Thames, J. H. Stoeckeler, and R. A. Tobiaski. Scheduled for presentation at 1954 meeting of Soil Sci. Soc. of America.

6. Soil moisture, trafficability, and forestry. K. G. Reinhart and R. S. Pierce. Planned for publication in Christmas Issue of Southern Lumberman.

Tallahatchie Research Center

Krilium Tests for Gully Planting

A study of the soil conditioning effects of "Krilium" on young loblolly pine planted on adverse gully sites was installed in May 1952 in north Mississippi. "Krilium" is a soil conditioner developed by the Monsanto Chemical Company for treating soils of high clay content to make them more porous and friable.

The study includes five blocks, all on relatively heavy clay subsoils typical of many hard gully bottoms and severely sheet eroded bare areas near the eastern edge of the Brown Loam section of north Mississippi. Site conditions among blocks range from poor to extremely adverse. Each block includes four treatments: (1) Krilium (formulation #6); (2) Krilium (formulation #9, a finer, more hygroscopic form); (3) cultivated without Krilium; and (4) no treatment (check).

Krilium was applied at a rate of one pound per 100 square feet of surface and thoroughly mixed to a depth of three inches. This resulted in a Krilium concentration in the surface three inches of about 0.04 percent of the weight of soil.

After two growing seasons, differences among treatments in average pine survival and height are not significant. Application of Krilium

to hard-packed subsoils typical of gully bottoms is both difficult and costly and, thus far, has failed to improve significantly either early growth or survival of loblolly seedlings planted on such adverse sites.

Forest Influences and Soils Project Analysis for North Mississippi and West Tennessee

In a project analysis approved in January 1954, studies initially proposed to attack mid-South problems of soil stabilization, land rehabilitation, and site evaluation (with limited funds and manpower available) include: (1) erosion control through use of grasses and legumes; (2) stimulation of pine plantations on severely eroded sites by fertilization and by use of legumes; (3) correlation of tree diameter growth with soil moisture; (4) changes in soil and soil moisture associated with conversion of worthless ridge hardwoods to loblolly pine; (5) soil properties under various tree covers; (6) root pattern characteristics with various soils; (7) correlation of tree height growth with physical and chemical properties of soil; (8) preparation of soil profile monoliths; and (9) preparation of charts of infiltration and permeability for major soils under various vegetative covers.

Pine Response to Fertilizers

A study to determine the effects of single and repeated fertilizer applications on survival and growth of loblolly pine seedlings planted on severely eroded sites was installed in north Mississippi in April 1954.

Three replications each of six treatments were installed on eroded loess and on eroded Coastal Plains soil. Treatments included application of nitrogen, phosphorous, potassium, and trace elements singly and in various combinations. Early the second year, a random half of each plot will again receive its original treatment.

Pine Response to Legumes

A study was installed in north Mississippi in April 1954 to determine the response of loblolly pine seedlings planted on adverse sites to interplanted herbaceous legumes.

Four replicated treatments were installed on sites of sheet eroded loess and of Coastal Plains soil. Loblolly seedlings planted 6 x 6 feet apart were interplanted with Lespedeza bicolor, Lespedeza sericea, and Trifolium incarnatum. A fourth set of plots without legume interplanting was included for controls.

Soil Moisture and Tree Growth

A cooperative study was installed in north Mississippi in April 1954 to determine the relationship between tree growth and soil moisture content as it varies from day to day and season to season, also to

obtain soil and soil moisture data for the Forest Service Vicksburg Infiltration Project. Tree growth is measured by a dial dendrometer and soil moisture by a Colman soil moisture meter.

Fiberglas units were set at seven depths to a maximum of 42 inches on each of three loessial sites with 16-year-old shortleaf pine cover. One site is moderately deep loess with no impeded drainage; another is shallow loess with a heavy clay subsoil; the third contains a weak shallow pan. Soil moisture and climatic data will be gathered over a two-year period together with radial growth data from representative dominant pines on each site.

Site Changes with Species Conversion

A study was installed in north Mississippi in March 1954 to determine the nature, rate, and extent of site changes--especially those affecting infiltration and retention of water--associated with conversion of ridge stands of worthless hardwoods to pine.

Treatments included three replications each of released loblolly seedlings planted at three spacings (4 x 4, 6 x 6, and 8 x 8) on each of three aspects (south, ridge, and north) plus controls.

Changes in physical and chemical properties of the surface six inches, related to watershed values, will be determined at intervals during the next 20 years. These properties include weight of surface litter, organic matter content, total pore space and size distribution, percolation rate, and volume/weight.